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An Illustrated Weekly Journal

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ENGINEERING

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AWAY WITH GUESSWORK

CAN leading articles be exciting? Or must they follow the tradition of leading articles in the "class" daily newspapers? The question is relevant this week because the subject is itself exciting. It is operational research, or, as the Americans call it, operations research. No doubt you have heard of it; you may even have applied it. If you have, you won't need a leading article to set you on the road that opens up totally unexpected approaches to greater efficiency and effectiveness in every branch of industrial and professional activities.

The opportunity to refer to operational research arises this week from a lecture given on Monday to the Institution of Production Engineers. It was the 1956 George Bray Memorial Lecture, delivered by Mr. Stafford Beer at a meeting of the Institution in Sheffield. Mr. Beer is head of the department of operational research and cybernetics at the United Steel Companies Limited. The fact that he is working for a large group of steel companies is significant because it shows that this modern method is applicable to a branch of production engineering which is based to a considerable extent on tradition. As a method—it is almost a philosophy—operational research is not confined to the modern mass production industries. It was developed during the war, at a time when it was realised that new and urgent military problems could only be solved by bringing in scientific people of various disciplines and presenting them with conundrums that were previously regarded as the special worry of the appropriate specialist.

Mr. Beer's lecture is long. Here and there, the reader who has forgotten the mathematical equipment he once had will be on the defensive. But that difficulty will not prevent him from gaining a lively appreciation of the scope for operational research in *his* industry. If he is not able to take up the study himself he can always engage someone who is practiced in the method, knowing that he will be able to give direction to the application of operational research in his works or office.

"The trouble," Mr. Beer says, "is that science itself is divided into highly specialised objectives . . . Thus everyone thinks, for example, of applying the science of hydrodynamics to hydraulic engines in a works; but few think of applying it to the analogous problems of the flow of a sliver of cotton through a doubling machine, or the flow of supplies of raw steel into a rolling mill. Operational research specialises in no particular science, but in the scientific method; it concentrates on targets which lie unnoticed among the official objectives of scientific application." "There are many questions," he finds, "relying for solution on judgment, guesswork or prejudice to which scientific conclusions can be reached by developing this technique of *applying* science."

As an example of the type of problem which can be tackled, Mr. Beer takes the case of a production department in which, over a period, some 20,000 machine-jobs have been carried out. How is the manager of the department to measure the effectiveness of the work? There is no space here to summarise the operational research method adopted—though the techniques are quite elementary and can readily be worked out—but the important thing is that the manager finally receives "all that he wants to know on a single sheet of paper; he has a statistical guarantee into the bargain that anything which is not on this piece of paper is behaving within the normal limits of chance variation." Another valuable application is to costing, where the ability to predict must be developed. Operational research can aid the accountant, by organising his data about raw materials, about overheads, and most of all about output rates.

As for the conduct of a business as a whole, Mr. Beer believes that whereas only a small increase of productivity can be achieved by everyone working harder, increases of perhaps 20 or 30 per cent. can be gained by an application of operational research, which would lead to smoother flow, better planning, better machine loading, better servicing, and better communication and control. It has been demonstrated that the unaided human brain, working on, say, a problem of production planning, evolves a plan that is some way off the most efficient; the plan appears to be the best that can be produced, but in fact, when operational research techniques are applied, its deficiencies are revealed for the first time.

These few examples from Mr. Beer's lecture give only the slightest hint of the scope for operational research. Reading a printed copy of the lecture one is left wondering whether there is any facet of engineering which would not benefit from the method. At a meeting of the Operational Research Society in London this week, five speakers sketched the operational research approach to transport problems. One of them, Professor M. J. Lighthill, showed that the laws which govern the flow of traffic (pedestrian, motor, etc.) are analogous to the laws of hydrodynamics. For example, a crowd of people leaving a football match and passing through a restricted exit behave collectively like water flowing down a steep slope: a wave pattern develops, and other waves may become superimposed due to other factors.

Perhaps, after all, leading articles refuse to be exciting. But operational research certainly is, and Mr. Beer's lecture is a very good introduction to the excitement.

* * *

Plain Words

The demand for engineers has placed a heavy load on university engineering departments, and the number of lecturers available is already proving inadequate. First-class teachers are drifting from the universities to industry and to technical colleges, and the failure to hold or recruit engineering staff of the right calibre gives considerable cause for alarm. If the Government is serious in its call for technologists, it must recognise the part played by the university lecturer and reward him accordingly.

The value a man places on his services is compound of many factors, but in an important sense it is the salary he can get for the job he prefers to do. The labourer is worthy of his hire is less a moral precept than an economic fact. Governments, always under pressure to reduce expenditure, are notoriously slow to recognise the laws of the market place. If indeed there is a shortage of university lecturers—a shortage which outweighs other needs and commitments—then it is for the Government to resolve the problem by adequate salary increases.

A step in the right direction is provided by the recent £3 million award for university salaries, but in the case of engineering departments, the scales are still unrelated to the wider context of alternative employment Thus even now the salary of a university lecturer (minimum £900 p.a.; formerly £700 p.a.) barely compares with that paid in a technical college, where a lecturer can to-day secure £1,200 per annum. When set beside those offered in industry, university salaries are even less adequate.

It might be suggested that university life and the freedom to carry out academic research is reasonable compensation for the salary differential; but nowadays the research worker is happy to trade his freedom for the expensive equipment that industry and the Civil Service can alone provide. University life is a doubtful privilege when it amounts to being overworked. The wives of lecturers can at best derive only a vicarious pleasure from the satisfaction of teaching, and are unlikely to be content with so small a prize for winning a clever husband. University teachers sometimes supplement their salaries by working as part-time industrial consultants, but no man can serve two masters well.

No doubt the suggestion that salary scales should differ between university departments would meet considerable opposition, and anything that militates against the unity of a university is difficult to approve. But a precedent exists, for medical faculties are already favoured in this respect. The time has come to adopt a more realistic approach. Do we want our universities to provide a sound engineering training? If so we must be prepared to pay the market price. Even the dedicated do not work for nothing.

DESIGN FOR A NARROW VALLEY

SALIME HYDRO-ELECTRIC STATION IS BUILT BENEATH THE SPILLWAY

Considerable water power development is taking place in Spain, to compensate for that country's lack of indigenous fuel resources. Among the schemes in which British firms are participating is the one which is being undertaken on the River Navia in the province of Asturias. This river rises in the mountainous district between Lugo and Ponferrada and, as will be seen from the map reproduced in Fig. 4, flows northward to enter the Bay of Biscay at a small fishing village called Navia, about 56 miles west of the port of Gijon. Although the river is only just over 70 miles long, its fall is over 1,300 ft., and this will be utilised in five stations—Doiras (54 MVA), Salime (140 MVA), Silvon (35 MVA), Suarna and Arbon.

Of these five stations the first has been in operation for some time, while that at Salime was recently inaugurated officially and is at present being used as a peak-load station. The others are in course of construction or are in the planning stage. When in full operation they will be utilised to supply the mining and industrial districts of Northern Spain, including the areas round Oviedo, Ujo and Santander. The exact position of the Silvon station has not been determined and is not shown on the map, but it will take its water from the Doiras reservoir, the capacity and head of which are to be increased by raising the crest of the dam about 10 ft. All the civil engineering work in connection with this development is being carried out by Saltos del Navia en Comunidad, which is a subsidiary of Electra de Viesgo S.A. and Hidroelectrica del Cantabrico S.A., two companies which supply power in the area. To give some idea of what is being involved in undertaking this development some details of the Salime station are given here.

Fig. 1 The restrictions in width can be clearly seen in the view looking down the spillway.

The dam is of the arch gravity type and has a uniform triangular section throughout its length, the slope being 5 per cent. on the upstream and 72 per cent. on the downstream face. The crest lies on a curve with a radius of 1,320 ft. and its height above the foundation is 434 ft., while its horizontal length is 825 ft. and its width nearly 30 ft.

The penstocks for the four 35 MVA sets, with which the station is equipped, are embedded throughout their length in the structure. Each is about 300 ft. long and has an internal diameter of 8·25 ft. They are equipped with a screen and butterfly valve at the intake, the latter being accessible through a gallery in the dam.

CONFORMING TO THE CURVE

One of the features of the Salime scheme is the spillway which is constructed over the power station. This unusual layout, the appearance of which will be clear from Figs. 1 and 3, was necessary owing to the local topography, for the River Navia flows for the most part in a deep narrow valley through high mountains, the total catchment area being 720 sq. miles. It is fed by melting snow as well as by springs and rainfall, a combination of conditions which at times leads to severe floods. The spillway had therefore to be built for a maximum flow of 70,000 cub. ft. per second, although the average flow is only 1,800 cub. ft. per second. The result is that at maximum flow it dissipates about one million horse-power in a narrow valley where there is a danger of landslides and avalanches owing to the steep inclination (about 45 deg.) of the strata and its slaty nature.

The surface of this spillway conforms to the curvature of the dam, and it is shaped to give a slight lift to the water as it passes over the power house, in order to reduce the pressure at this point to some extent. On reaching the foot, the water flows over a row of "dragons' teeth" into a stilling basin, so that it is aerated and cavitation of the floor is prevented. It is finally turned back on itself by the downstream retaining wall.

Owing to the shape of the spillway surface, the roof of the station slopes and the four generating sets lie on an arc with a radius of about 1,020 ft. Consequently, the overhead crane runs on a curved track and has larger diameter wheels at the upstream than at the downstream end. There are three main transverse bays beneath the spillway. Of these, the power house occupies that in the middle, the tailwater chamber the lowest, and in the highest is the main control room with the metering and relay boards, as well as the 380 volt switchgear. A platform on the left bank of the river alongside the stilling basins carries the four main transformers and the 140 kV switching station, as shown in Fig. 1.

The water in the tail-

race chamber passes through a free-flowing tunnel with an internal diameter of about 23 ft., which runs under the substation and discharges into the river just downstream of the counter-dam of the stilling basin, thus ensuring stable tailrace conditions.

PROBLEMS OF HEIGHT AND WIDTH

The power station is of the "one-floor" type, all the plant and equipment, including the main valves, being directly accessible to the crane. The width and height had to be reduced to a minimum so that there should be no encroachment on the 72 per cent. downstream profile of the dam and so that the spillway should be kept as low as possible. These conditions were met by adopting a curved longitudinal instead of the normal straight horizontal axis. In addition to keeping to a minimum the height of the crane hook needed for lifting the rotor out of the stator, the turbo-alternator shaft was divided into three sections instead of two, and the pilot exciter was partly telescoped inside the main exciter.

In order that the turbine runner can be dismantled from below, the throat of the draught tube has been made removable. This enables the runner to be lowered on to a truck, which can then be run out on rails into a pit where it comes directly under the crane. Major overhauls can thus be carried out without disturbing the alternator.

The main inlet valves, the turbines with their draught tubes and auxiliary equipment, as well as the main alternators, transformers and the high and low-voltage switchgear, were all supplied by the English Electric Export and Trading Company, Limited, Kingsway, London, W.C.2. The same firm has also obtained the contract for the first generating set for the Silvon station.

The turbine valves, which have a bore of 5 ft. 10 in., are of the "straight-flow" type, and are operated by a servo-motor, the movement of which is regulated by a travelling screw. This progressively diminishes the speed of closing and thus prevents water hammer. The valve door is hemispherical so that the water is cut through without being deflected. Safe closing in emergency is therefore possible. A double rubber seal is provided so that inspection or replacement can be effected without emptying the water in the pipeline.

The main turbines are of the vertical shaft Francis reaction type and run at 300 r.p.m. Their maximum output under a net head of 370 ft. is 50,000 h.p., while at the minimum working head of 228 ft. it is 21,000 h.p. The spiral casings of these sets were welded to the speed ring at the works, and the whole assembly was then divided into four parts for dispatch owing to the difficulties of approach to the power station. The sections were then bolted and welded together on site and after testing were embedded in the concrete foundations.

The runners are fabricated, the stainless steel blades being formed to shape before being welded into the crowns and skirts. The guide vanes and their trunnions are of mild steel, while the regulating rings are of welded steel with gunmetal gliding pads and are provided with cast-iron guide vane levers and links and

Fig. 2 The power station is built below the spillway and follows the curve of the dam. The centre section of the spillway forms the roof of the power house, as shown in Fig. 3.

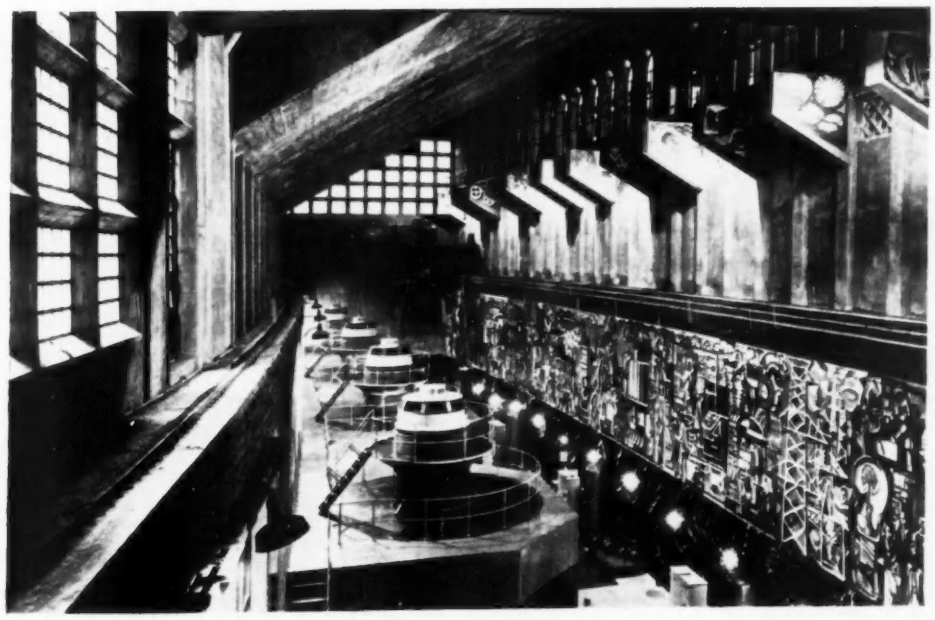

Fig. 3 The four 35MVA sets at Salime are arranged on the arc of a circle. The overhead crane that serves them also moves along an arc.

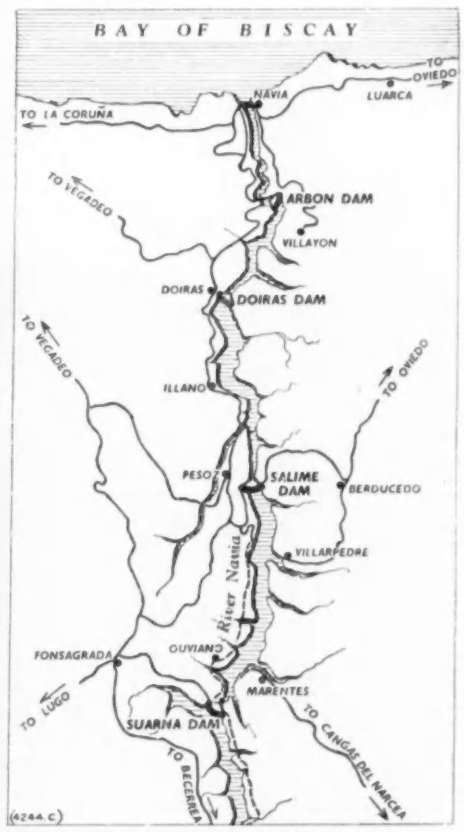

Fig. 4 Map of the hydro-electric development on the River Navia in Northern Spain which is now in course of construction to make up for the country's lack of fuels.

two steel rods which are directly connected to the operating servomotors. The governors are of the normal English Electric design.

Each alternator has an output of 35 MVA at 11 kV and a power factor of 0·9. They are of the vertical-shaft two-bracket type, a combined thrust and guide bearing of the pivoted pad pattern being mounted on the upper bracket above the rotor, and a second guide bearing on the lower bracket below the rotor. Both bearings run in a common pot through which oil is circulated by a pump driven by an alternating-current motor with one driven by a direct-current motor as stand-by. The stator frames were divided into two parts for transport, while the rotors were assembled on site by shrinking the steel hub packets on to the shaft and then fitting the salient poles. Both the poles and the hubs are dovetailed, and are fitted with taper side keys in the slots of the latter to facilitate removal for repairs. Closed-circuit cooling is employed. The small alternators, from which power is supplied to the actuator pendulums of the turbine governors, are mounted on extension shafts directly above the thrust bearings, while above them again are the main and pilot exciters.

TRANSFORMERS AND SWITCHGEAR

The main transformers, to which the alternators are connected, have a no-load ratio of 11/140 kV. As the neutral point of the system is solidly earthed it has been possible to employ graded insulation on the 140 kV windings with tapping points connected in the neutral end of the coils to give ± 2½ per cent. and 5 per cent. variation. The tap-changer is manually operated from the exterior of the tank. The oil is cooled in two oil/water heat exchangers through which it is circulated by a pump. The auxiliary and common services in the station are connected to four 800 kVA 11,000/380 volt unit transformers, the arrangement being such that each alternator supplies its own auxiliaries.

The 11 kV switchgear consists of isolators so that each alternator can be disconnected from both its main and unit transformer. With the exception of the governor oil pump, the main turbine and alternator lubricating oil pumps and the alternator heaters, all the main machine auxiliaries and the other station and local services are supplied at 380 volts from a common services board which is fed from any one of the four 380 volt unit boards. The oil pumps and the alternator heaters are supplied direct from the unit board of the set. All these switchboards are equipped with air-break draw-out circuit-breakers and "Combination" fuse switches.

The 140 kV substation is of the "high" type in which the isolators and busbars are placed vertically above the circuit-breakers owing to the restricted space alongside the stilling basin. The circuit-breakers are of the English Electric air-blast type with two interrupters in series per phase, and with a rupturing capacity of 2,500 MVA. All the feeder breakers are provided with high-speed auto-reclose control.

Letters to the Editor

INTERCOOLING IN GAS TURBINES

SIR, I found Dr. B. W. Martin's article on the effect of high temperatures and of intercooling on the efficiency of gas turbines (ENGINEERING, March 1, page 272) most interesting. But I think that the author's analysis of different gas turbine cycles might have been improved if he had not assumed that the total work of compression in an intercooled cycle is shared equally between the compressors. This assumption leads, of course, to the maximum specific output of the gas turbine, but not to its maximum efficiency; the only exception is the merely theoretical case of a gas turbine provided with a heat exchanger having a thermal ratio of 100 per cent.

I showed in my book on thermodynamics of the gas turbine* that for a gas turbine without reheat or heat exchanger, but with an intercooler, the substitution of the optimum division of work between the compressors for equality increases the efficiency by about 7 per cent. The improvement is still higher when the number of intercoolers is more than one. Likewise, when the cycle uses reheat, the total work of expansion must not be shared equally between the turbines, as there is a law of division leading to the maximum efficiency. In both cases, the division of work (of compression or expansion) depends on the individual efficiency of the compressors and turbines and on the thermal ratio of the heat exchanger.

It is quite true that the chief interest of reheat and intercooling is their effect on the specific output of a gas turbine. This statement can be illustrated by the Brown Boveri gas turbines with a reheat combustion chamber and an intercooler, designed for an inlet temperature of 650 deg. C. and an output of 22,500 kW. But the effect of reheat and intercooling on their efficiency is far from negligible: the above-mentioned gas turbines have an overall efficiency of 24·2 per cent., and it is well known that, with a plain cycle and the same inlet temperature, it would scarcely be possible to reach an efficiency higher than 20 per cent.

To sum up these remarks, it seems that the idealisation introduced by Dr. Martin into his analysis cannot be easily justified. It is obvious that if Dr. Martin, instead of assuming the same work input for each of the compressors, had taken into account the effect of the division of compression work on the efficiency, some of his conclusions would have been modified and, among them, the efficiency curves of Figs. 16 and 17.

Your faithfully,

P. CHAMBADAL.

Électricité de France,
Centre des Études & Recherches,
Service Thermique,
3 Rue de Messine,
Paris, 8e.
March 13, 1957.

* *Thermodynamique de la Turbine à Gaz* (Paris, Hermann et Cie., 1949).

★ ★ ★

COMMENT—1

SIR, The letter on the "Bare Platform," published on page 293 of your issue of March 8, has prompted me to write to you, and, if my remarks are considered unduly critical, it may be pointed out that when people get old they generally think that things were better when they were young!

Having taken ENGINEERING from my schoolboy days and being now long past the 80th milestone, I have a complete set covering over 70 years and feel that I know it very well. In my opinion, the paper has deteriorated in some ways since it took on its "New Look" some years ago. I do not refer, of course, to the cover pictures, which are excellent, though it is often disappointing not to know more of the subjects illustrated.

At one time, ENGINEERING was probably the premier paper of its class in the world. The articles, illustrated from working drawings, and the two plates (which I presume have gone for good), on all branches of engineering, were a great feature. Of course, great changes are taking place and your readers are being kept well informed of the rapid advances in nuclear engineering, but the detailed description of bridges, ships, marine engines, turbines, dams, etc., seem to be quite neglected now, and a good deal of the paper has become a high-class catalogue, illustrated by photographic views.

Some of the subjects dealt with seem to me to be unsuitable. At the time of the last General Election there was a leading article entitled "The Two Manifestoes." I did not read it as I thought party politics might be left out. The article on the "Shape of Things" in the issue of October 19, 1956, was no doubt suitable for an ultra-modern Art paper, but it was, I thought, quite out of place in ENGINEERING.

I should have thought that we heard quite enough about the Americans without having to pay two shillings for a nearly life-size portrait of a "tough guy" of an American engineer, however capable the gentleman may be.

ENGINEERING now seems frequently to go from the "sublime to the ridiculous." In last week's issue there is an exceedingly technical article on brake drums, and on the last page there is a silly story about Italians hiding under railway carriage seats. Some time ago there was a paragraph on the objections to eating fish and chips in omnibuses!!

I have been puzzled to understand what this has to do with engineering.

I am,

Yours faithfully,

W. H. NEWMAN.

North-road,
Ditchling,
Sussex.
March 15, 1957.

★ ★ ★

COMMENT—2

SIR, I can contain my appreciation of ENGINEERING no longer, but feel forced to write immediately congratulating the staff of your magazine on the magnificent job which is being done. Issue succeeds issue, each attaining an extremely high standard, not only of layout and typography, ensuring maximum identification of text and illustration, but of taste and style too, ensuring coverage which not only covers every major endeavour in the engineering field but which digs beneath the surface appearance uncovering background and motive.

The writing is informative and leisurely, daring to step outside the stereotyped limits of normal business and trade publications. It expresses the true spirit of scientific humanism.

Yours sincerely,

BRIAN H. TAYLOR,
Managing Editor.

Pulp and Paper Magazine of Canada,
Gardenvale,
Quebec,
Canada.
March 12, 1957.

★ ★ ★

EARLY AERONAUTICS

SIR, From its earliest days, your journal has taken an acute interest in aeronautics. Its early articles, by authors such as Horatio Phillips, are still classics to historians and it is in the interest of these historians, that I am now writing. This is a period when there is a tendency for valuable aeronautical papers to disappear. Frenzies of spring-cleaning, office-moving and general clear-out cause old papers such as diaries, photographs, and handbooks of engines and structures to be thrown into dustbins.

All I ask is for the material—whatever it is—to be sent to me (or I will collect it).

The Royal Aeronautical Society is, of course, the oldest Society in its sphere in the world and it is to us that chroniclers look for the answer to the "impossible" question. We try not to disappoint them and a great step in this aim is the collection of the apparently useless.

Yours faithfully,

F. H. SMITH,
Librarian.

The Royal Aeronautical Society,
4 Hamilton-place,
London, W.1.
March 8, 1957.

Weekly Survey

Cover Picture: *Ferroxcube is a non-metallic magnetic ferrite which is widely used in the electronics industry because of its excellent magnetic properties. It finds its main applications as cores for transformers and inductors, as aerial rods, for the "memories" of computing machines and in magneto-striction devices. The illustration shows the material being extruded in the form of rod for subsequent machining.*

★ ★ ★

The Strike

Foolhardiness, prejudice and narrow self-interest combined to produce the shipyard workers' strike. It is the biggest strike since the war and likely to prove one of the most damaging. It will doubtless do great harm to the industry's prospects for, as Mr. Watkinson pointed out, a knock-down, drawn-out battle is unlikely to benefit anyone except the industry's foreign competitors. But it could do some good—if only by clearing the air and making the really important issues at the yards stand out. One thing is clear: the level of wages is not the vital issue that both the men and the employers pretend. Essentially it is a crisis of confidence arising from the industry's own past. All, or nearly all, that has happened since the war—the failure to raise productivity to any significant extent, the failure to modernise and re-equip, the continuous bickering about demarcation, the endless scuffles between management and labour over minor issues—all these and more are evidence that shipbuilders and shipyard workers alike lack full confidence in their future. Dynamic industries do not mind how much they pay, or how much they invest. Nor do they need to fear paying or investing too much, for their very dynamism carries them forward to further expansion, cheaper methods of production and bigger markets.

The greatest single need of the shipyards is for more output, to keep down order books and so share fully in the world's seemingly (and demonstrably) limitless demand for modern tonnage. More and quicker output means not only more modern equipment and improved techniques but a great deal of time and method study and fewer restrictive practices. There is an urgent need for better management-labour relations, which can only be brought about through better communications and more applied common sense. But basically it is the lack of confidence in the future, the fear that once again "grass will grow on the slip-way," which is the cause of the present conflict. Higher pay could be both a spur to modernisation and a result of it. It need never be a bone of contention in a prosperous and progressive industry.

The unanimous decision of the Confederation of Engineering and Shipbuilding Unions to call a strike in the engineering industry to-morrow is a most serious threat to the nation's livelihood. As in the case of shipbuilding, the rejection of the 10 per cent. pay claim is the reason given, and in particular the rejection of the claim prior to any having been made. This was at the height of the Government price-freeze movement; conditions have changed and some increase is now obviously warranted in both cases. Why not, then, agree to submit the whole matter to the adjudication of so eminent and respected a person as Lord Evershed?

★ ★ ★

Call for Nickel

The shortage of nickel is unlikely to be relieved for at least another five years, despite the very large expansion programmes of the industry. The switch to substitute materials which has already begun is thus likely to be accelerated, and this prospect is causing anxiety to producers. The point is stressed in the annual report of the International Company of Canada published last week. The company are "greatly concerned" that civilian consumption should continue to be curtailed by "the shortage remaining after satisfying the large defence requirements."

The fact that defence and stockpiling dominate the market to the extent of 40 per cent. of total deliveries must introduce a major element of risk in continued expansion. It would not be the first time that the United States stockpiling programme has led to considerable over-production of basic metals. Yet there is little the producers can do but accept the risk and rely on assurances given them by the authorities. International Nickel, who account for over 60 per cent. of nickel production in the Western Hemisphere, have therefore started a vast new programme of expansion. They are spending 175 million dols. on the exploitation of deposits in Manitoba, which is expected to increase their output by 100 million lb. a year to 385 million lb. within five years. Other schemes are planned in Cuba, the United States and New Caledonia, and several more are expected to be initiated in Canada during the next few years. To sustain the level of production likely to result from these, is now one of the main preoccupations of International Nickel and their competitors. They are investing heavily in research to develop new uses for the nickel, and relying on their stable price policy to encourage demand.

The heavy expenditure in exploration—over 8 million dols. was spent on searching for nickel ore deposits in 1956 by Inco alone—suggests that despite the uncertainty introduced by stockpiling there are good prospects of increasing demand for civilian uses. Among the most promising are listed "atomic energy; jet engines for use in airplanes; gas turbines for use in industrial power plants, ships, trains and automobiles; as well as new steam power plants designed to operate at higher temperatures and pressures in order to increase efficiency." This is as unequivocal a statement of faith in the gas turbine for industrial and automotive applications as has been published for some time.

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Cobalt Usage

The first general meeting of the Cobalt Development Institute was held in Brussels at the end of February. The Institute was created in January this year by the world's leading cobalt producers in order to develop in all countries existing uses of cobalt and to search for new ones. It has entrusted the execution of the programme to a Belgian limited liability company, the Centre d'Information du Cobalt, and is represented in the United States by the Cobalt Information Center installed at the Battelle Memorial Institute in Columbus, Ohio.

The background to this development is provided by the rapid increase in world production capacity for cobalt and relative stagnation in consumption. In 1952 there was a serious shortage of the metal due mainly to a rapid expansion in consumption of high-cobalt alloys for aircraft gas-turbine blades, mainly in the United States, and to heavy purchases for the United States stockpile. As a result of this shortage a number of consumers in other fields began to use alternative materials. Since 1952 there has been a considerable fall in the United States consumption of cobalt for high-temperature alloys, and consumption for the other main uses, namely permanent magnet alloys, alloy hard-facing rods, cemented carbides and high-tensile steel, has not expanded sufficiently to maintain the level of total consumption.

At the same time the high prices during the period of shortage have encouraged a marked expansion in production capacity which is estimated to have risen from about 26 million lb. in 1953 to nearly 40 million lb. in 1957. World production rose from about 24 million lb. in 1953 to 26 million lb. in 1954 but there was little further increase in 1955. About two-thirds of the total output is accounted for by the Belgian Congo. As a result of the growing potential over-production the price of the metal has been reduced from 21*s.* per lb., the level prevailing in the United Kingdom throughout 1954 and 1955, to 16*s.* per lb.

While cobalt is likely to remain of strategic importance as a necessary component of certain alloys for jet engines, it seems improbable that total consumption for this purpose can be expanded to any great extent. In the field of permanent magnets, high-cobalt iron alloys are meeting increasing competition from other materials, particularly ferrites and ceramic magnet materials. The General Electric Company of America, moreover, recently announced the development of another competitive magnet made by dispersing iron particles in a plastic matrix. While these new materials are by no means competitive over the whole range of permanent magnets, their increasing use will probably make it very difficult to expand total cobalt consumption in this field. On the other hand, consumption of cobalt for a number of purposes, for example corrosion-resistant alloys, has undoubtedly been very largely restricted owing to the high price of the metal and there is probably scope for a number of new uses if the price can be substantially reduced.

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Rising Steel Output

The latest statistics of steel production, those for February, suggest that the industry should make its target figure for the current year, set by the Iron and Steel Board at 22·4 million tons. Output in February was at the rate of 432,100 tons a week, or 22·5 million tons a year. It is now unlikely that production will be checked by shortages of fuel this year.

The industry's chief problem continues to be the planning of new capacity. There still exists a cushion of imports and a high export demand which serve to shield the industry from any fall in demand for some of its products, as took place last year in the case of the motor industry. The shipbuilding strike could considerably relieve the pressure of demand on the capacity for plates and heavy sections. The Board report a continuing strong demand from the coal and railway wagon building industries, and it is doubtful if there would be any slack even if the shipyards were idle for a long period. The export demand for this type of steel is considerable (exports are limited) and there would be no difficulty in disposing of any surplus at attractive prices. Yet people in the steel industry are becoming concerned over the apparent inability to increase British overall industrial production. There has been no significant change for the past two years, and the latest Board of Trade information on capital expenditure by manufacturing industry suggests that the rate of increase is slackening further.

Opinions vary concerning the probable consumption of steel by industries this year. The substantial recovery of demand for motor vehicles and household appliances will almost certainly reverse the recent trend in sheet consumption. The demand from manufacturers of electrical generation plant, rolling stock, mining and mechanical handling plant and from shipbuilders shows no sign of slackening. The demand from the constructional engineering industry may fall, but not heavily. On the whole therefore—barring prolonged strikes—imports are likely to be required, though at a reduced level, during the remainder of the year.

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Rhodesian Steel

A further step was taken at the end of last month towards development of the Federation of Rhodesia and Nyasaland when an agreement was signed at Salisbury for the transfer of the

assets of the Rhodesian Iron and Steel Commission to a new company, Rhodesian Iron and Steel Company (Private), Limited. The Riscom works at Que Que has a capacity of about 50,000 tons of steel a year and negotiations have been in progress for about 18 months with a view to expansion of capacity in order to utilise the very large reserves of 60 per cent. iron ore which exist in the neighbourhood. Until comparatively recently the Que Que works were operated at a loss but for the past year the Commission's accounts showed a profit of about £50,000 after meeting an annual interest charge of £200,000 on Government loans. It has, however, been recognised for some time that for successful exploitation of the reserves a considerable expansion of capacity and a programme of integration would be required.

The participants in the new company include the Lancashire Steel Corporation and Stewarts and Lloyds, who will be jointly responsible for management, and also the Messina (Transvaal) Development Company, the Anglo American Corporation of South Africa, the Rhodesian Selection Trust, the British South Africa Company and Tanganyika Concessions. The purchase price has been agreed at £4 million and in addition the new company will buy from Messina (Transvaal) the iron ore deposits near Bukwe and neighbouring limestone deposits. Proved and probable iron ore reserves already amount to 134,500,000 tons.

Over the next five years it is proposed to erect coke ovens and to expand capacity to 150,000 tons of steel a year and between 500 and 600 tons of pig iron per week. In addition, it will be necessary to expand the carrying capacity of Rhodesia Railways in order to cope with the large quantities of coal which will have to be moved from Wankie to Que Que and the surplus pig iron from Que Que to the port of shipment. In order to assist in financing the development programme the Government, which will receive £3½ million of the purchase price in the form of 4 per cent. redeemable second debenture stock, has agreed to re-invest its debenture interest for five years. It has also been agreed that no dividends will be declared for five years, all profits during that period being ploughed back.

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Oil in Plenty

All those concerned with oil supplies in western Europe have been commendably cautious in the past few months of crisis. No one could with any certainty have said last October that 94 per cent. of the total requirements would be met without any oil flowing either through the pipelines of the Iraq Petroleum Company or in tankers through Suez. Yet this was the case two weeks before the Syrians agreed to the repair of the I.P.C. pipelines and the Egyptians began to remove explosives from the last major obstruction in the Suez Canal. The oil committee of O.E.E.C. then announced that western Europe was unlikely to be short of its full requirements by much more than 5 per cent. during the second quarter of this year. Now a surplus might easily result from the resumption of shipments through Suez and from East Mediterranean ports. Already producers in Louisiana and Texas are cutting back production slightly to prevent a glut.

In Britain petrol stocks are now so high that refinery output may have to be reduced unless the seasonal increase in demand empties some of the storage facilities. There is little doubt now that de-rationing is imminent. Some find it hard to understand why it has been kept on for so long. The answer was given by Mr. Watkinson, the Minister of Transport and Civil Aviation, last week in a speech to the Road Haulage Association: "We have been able to show that the use of the Suez Canal is far less vital to us than many people thought a few months ago. Now we are certainly not in the position of having perforce to use the Canal at the earliest possible moment, or on the most unfavourable terms." Rationing is there to strengthen our bargaining position.

Taking a longer view, it is essential to build up in the Middle East the goodwill and political stability which will not only ensure a continuity of flow but permit a considerable increase in production. A recent study published by Mobil Oil Company—"Western Europe's Oil Problems," by Mr. P. C. Ingalls—concludes that "as long as Middle East production is available, it is unlikely that the western hemisphere will produce enough to keep up with its own demand," since there is a normal decline in production from existing wells of about 8 per cent. per annum which has to be made up by continuous oilfields expansion. Another authority, Mr. D. A. Shepard, a director of Standard Oil (New Jersey), said that output from the Middle East would have to be doubled in the next twenty years to meet anticipated growth in demand from western Europe. It was the only area which could do so, provided the "rather staggering sums of capital" required can be invested with safety. Certainly the Middle East cannot prosper without Western demand or develop further without Western capital. This is by far the best insurance we have of continued supplies. A substantial increase in storage capacity, particularly for medium and heavy distillates, would go far to provide short-term cover against a recurrence of the Suez crisis. The provision of large round-the-Cape tankers will also help, but neither is a substitute for political wisdom.

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Roads for Europe

The approval recently given to a 13 kilometre tunnel under Mont Blanc "to facilitate the movement of goods across Europe" has coincided with the British Government's announcement on projected expenditure on roads. Speaking in the United States about the tunnel, Mr. Douglas Clark, executive director of the International Roads Federation, explained that for the cost of 237 million dols. (£85 million) a highway would be opened up between France and Italy, able to handle more cheaply the heavy volume of goods now moved by ship through the Mediterranean. This is part of a grand design for a road network for Europe, planned by the Economic Commission for Europe with the co-operation of the International Road Federation. Main roads numbered from E.1 to E.30 link all main towns, e.g., E.1 links London, Paris, Nice, Genoa and Rome, E.12 links Paris, Nuremberg, Prague, Moscow, etc. The network includes branch roads numbered from E.31 to E.100. The scheme is comprehensive and is designed for development within the concept of the common market, although the whole of Europe is included. Four main highways, E.1, 2, 5 and 8, reach London but none go beyond it.

A working party was appointed in 1950 by the E.C.E. subcommittee on road transport, to study the problems of international highways, their necessary characteristics (including a simpler customs procedure at the frontiers) and to determine the conditions under which they should be constructed and financed. These activities were referred to in a pre-Budget letter written by Lord Derwent, chairman of the British Road Federation, to the Chancellor of the Exchequer. Pleading for greater expenditure on British roads he writes: "I can assert with conviction that whatever the conception of a European Free Trade Area may bring forth, modernisation and expansion of the road systems in the proposed participating countries is already proceeding at a pace and will continue to do so to a measure that will increase still further their competitive power . . . Such developments must be viewed with alarm."

The increase in the Government's proposed expenditure in the next financial year by £12 million, to £59 million, is to be welcomed. In relation to the country's needs, however, and to expenditure under other headings, it is pitifully small and tragically inadequate. Truly, as Lord Derwent said, the failure of successive Governments since the war to provide Britain with a modern road system is "one of the unaccountable phenomena of modern times."

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The Coal Board's Dilemma

Colliery stocks at the end of January were half a million tons higher than in January, 1955, and 121,000 tons above January, 1956. In addition, stocks of 1,103,000 tons were held on central stocking grounds or opencast sites. All told, stocks were up by over a million tons on a year ago. Does this mean that the coal industry has at last turned the corner? The answer is that, on the contrary, the Coal Board is running into a number of new difficulties.

The increased stocks reflect the mild weather which has not only cut demand but has reduced absenteeism and delivery hold-ups. As exports were down to a monthly average of 162,000 tons in 1956, it might be expected that some of the surplus coal could be sold overseas. In fact, official policy is to put most of it into store. There are two reasons for this. The first is that coal exports cannot be turned on and off according to the United Kingdom stock position. The continental countries that were formerly customers for British coal have now signed long-term contracts with the United States in order to secure regular supplies. The second factor is that much of the surplus consists of poor quality small coal.

The truth of the matter is that the N.C.B. now finds itself in a vicious circle which is inevitably bringing about a quality problem. The shortage of labour demands increasing mechanisation. The machines used break up the coal so that more and more of the total output is in the form of small coal and dust, which has only a limited number of uses and is not suitable for export. The rejection by the miners of the Board's offer to revise the system under which a bonus is paid for five consecutive days work on condition that foreign labour, and in particular Hungarians, were accepted, means that the main hope of solving the production problem is going to be further mechanisation.

In short, the Coal Board is faced with the dilemma that the production problem can only be solved at the expense of quality. This is a dilemma for which a solution will not easily be found.

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Signalling for 50 Cycle Electrification

Contracts have now been awarded by British Railways for signalling work on two of the sections where trials of 50 cycle locomotives and motor coaches are to take place. The first of these went to the Siemens and General Electric Railway Signal Company for installations on the Colchester-Clacton-Walton lines of the Eastern Region, and the second to the Westinghouse Brake and Signal Company for the Wilmslow to Slade Lane Junction section of the Manchester-Crewe line. On routes outside busy urban areas it may often be practicable to use single-rail direct-current track circuits on a 50 cycle line, with the return traction current confined to the second rail, and direct-current signalling apparatus being protected against alternating-current interference by means of series inductances. The opportunity is being taken, however, to put in equipment suitable for the more exacting conditions where both rails are required for the traction current, when the track circuit supply, which shares the same rails, must be differentiated by frequency, coding, or a combination of both these methods. It has been announced that the Westinghouse apparatus will operate directly from an alternating-current supply of the same fre-

quency as that used for traction. Another possibility is a track circuit supply at 83⅓ cycles derived from motor-generator sets.

On the Continent, electronic apparatus is being used to generate a track-circuit frequency of 1,000 cycles per second, but even then coding is required as well and it has been argued that adjacent track circuits should be fed at different basic frequencies in case a breakdown of insulation between them might result in a false " unoccupied " indication. One special problem which signal engineers in this country have to face is the production of apparatus which, while suitable for 50 cycle traction, will operate safely on lines now worked at 1,500 volts direct current pending their conversion to the alternating-current system. This need will arise first on the lines from Liverpool Street to Chelmsford and Southend, where the track circuits have been converted only recently from direct current to 50 cycles alternating current for immunity from the direct-current traction system at present in use.

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The Mechanics of Golf

Speaking at the jubilee dinner of the Engineering Golfing Society last week, Lord Brabazon was able to discuss the technicalities of golf in a way that would not have been possible with a less technical audience. Who but engineers could add to the sporting and social attractions of the game an appreciation of its other varied facets—aerodynamic, mechanical, statistical, not to mention hydrodynamic?

Referring to the practical difficulty of adequately specifying the characteristics of the golf ball, Lord Brabazon (a past-captain of the Royal and Ancient) recalled the American attempt to insist that the ball, when struck by a club moving at 140 ft. per second, should not exceed a velocity of 240 ft. per second *in vacuo*. It would hardly be convenient to have a testing machine in every club-house; the Americans had had one, but even that had since been dismantled. It had been found, he said, that the standard indentations (0·01 in. deep) on the ball gave the optimum aerodynamic performance. As for the modern golf club, he said it was a " mechanical aid " since the steel shaft much reduced the tendency to twist, as compared with the old wooden shaft. The danger of a slice was consequently also reduced.

The Engineering Golfing Society was founded 50 years ago for golfers who are members of one of four professional institutions (I.C.E., I.Mech.E., I.E.E., and the Institution of Engineers and Shipbuilders in Scotland). They hold two meetings every year, in the spring and autumn, but this was the first formal dinner to be held. The chair was taken by the president, Mr. Geoffrey H. Hopewell, who responded to Lord Brabazon's speech proposing the toast of the society. Mr. John A. Dixon proposed the toast of the guests and Mr. Henry Longhurst replied.

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Continent and Commonwealth

A strong plea was included in the directors' annual review of Hoover Limited for British participation in a European Common Market. Calling the probable establishment of such a free trade area " the most important development of the moment," the directors go on to say that " Britain must inevitably be closely associated with this structure " and that in their view opportunities for British manufacturers are " immense." They emphasise the existing facilities the company have already established in those countries and point out that their exports to them are already at a high level. The efforts to develop overseas business announced in last year's review yielded a 16 per cent. increase in exports: the company now export over 70 per cent. of vacuum cleaners and washing machines.

Sir George Nelson's comments on the proposed integration of European trade are more guarded. He expressed deep interest in the proposals but added " it cannot be denied that there are dangers in them." One of the main dangers, in his view, was the possible adverse effect on Britain's trade relationships with the Commonwealth. We should not contemplate the possibility of some of the countries " being absorbed in one or the other " of the major competing trade blocs in the world—" the United States, Europe, and, in the future, Soviet Russia and China." Other dangers were that we should find the cost of labour to European manufacturers to be lower than in this country, and that their design standards are different.

Much depends on the standpoint of the manufacturer concerned. There is little doubt that for industries where British manufacturers have developed large batch production techniques, or have largely mechanised manufacturing processes, a fully integrated European trade would be a wonderful opportunity. Hoover are a very good example of this. There are others in the same field of domestic appliances, motor vehicles (provided body designs are suitable), Diesel engines, small electric rotating machines, and others. Where, however, labour is a major component of the cost, as in heavy electrical plant, locomotives, steelworks plant, and certain types of machine tools, competition under present conditions would be severe.

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Helicopters for Germany

The second major order placed by the Federal German Government with a British aircraft manufacturer was announced on March 8. The contract is for fifty Bristol 171 Mk. 14 Sycamore helicopters, valued at several million pounds, and is claimed by Bristol to be one of the largest ever placed with a helicopter manufacturer. Some preliminary and tentative details of probable German orders have been known since the middle of last year; the list includes five British aircraft, and letters of intent were sent to the five manufacturers last November, confirming proposed contracts to an estimated value of some £17 million. The first contract to be signed was that for Hunting Percival Pembrokes, signed in January, to the value of over £2 million. A figure of 80 has repeatedly been mentioned as the probable order for Sycamores but, in the event, the number is less.

The Sycamore is a five-seat helicopter powered by the Alvis Leonides piston engine; in fact Alvis are doing well out of the present orders since the engines also power the Pembroke. The Sycamore is already in service with the R.A.F. and has several years steady development behind it, particularly in tropical climates and at high altitude. It is also in use by the British Army, the Royal Australian Navy, the Royal Australian Air Force, British European Airways and Australian National Airways.

Now that Germany is placing firm orders it is interesting to compare the contribution of the various producing countries to the provisional programme of last year. Of the overall purchasing programme of just over 2,000 million marks, 44 per cent. were to be supplied by German manufacturers, building for the most part under licence, the main licensors being French companies. The direct United States contribution was to be 136 million marks or only 6·7 per cent., but if production of American Sabres in Italy is included this proportion rises to over 40 per cent. The remaining 16 per cent. is made up of direct supplies from Britain, France and Italy, the British contribution being 191 million marks or only 9·4 per cent.

The large direct and indirect American contribution is to be expected, but the success of French designers may be worth bearing in mind as an omen of future competition in export markets. But the Bristol success should not be underestimated. This order represents a large proportion of the proposed German helicopter purchases, and in view of the immense service experience built up by the Americans with helicopters, this is a significant step forward.

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Electrifying Progress

The development and research programme of the North of Scotland Hydro-Electric Board contains several items of absorbing interest. Foremost among these, and perhaps least expected in a report of this kind, is " research into the life of the salmon, smolt rearing and other fish conservation activities." The easy explanation is that the Board are responsible for an area of water probably greater than that of any other area Board in the United Kingdom, and therefore for the fish therein. Experiments are being made " to improve the design of electric fish screens " and development work carried out on electronic fish counters " for the purpose of adopting them for use with the Borland fish lock." Trials of underwater television as a means of inspecting screens, intakes, etc., were made in conjunction with the Marconi company.

Some considerable enterprise was displayed in finding and perfecting new outlets for electricity, and in connecting new consumers. The Board emphasise the considerable distances per connection required in their area but have nonetheless connected an average of 18,500 consumers a year for the past eight years. Total capacity has increased from 251 MW in 1949 to 808 MW in 1956, and output from 710 million to 1,744 million kWh in the same period. Over four-fifths of total capacity is now water power, compared with about one third in 1949. The Board are most active in the development of pump storage schemes " because of the flexibility and operating advantages they offer in association with large nuclear and high efficiency conventional steam stations." Nuclear power is being considered to provide part of the thermal generation required to meet increasing load and to provide support for hydro-electric generation in times of drought. Wind power is also of interest to the Board, who will " continue to watch the experiments " on the problem of producing power from wind in the Orkneys. This work has recently been taken over by the Electrical Research Association from John Brown and Company (Clydebank) Limited.

Despite the considerable progress which has been made since 1949, only 55·5 per cent. of the farms and 55·4 per cent. of the crofts in the area have electric supply. Much remains to be done, but the popularity of electricity in the highlands for space heating is such that demand continues to grow at a high rate (by 10 per cent. in 1956). The fact that the average cost of electricity in 50 Inverness all-electric flats was only £36 in the second year of occupation suggests that, given suitably designed premises, electricity can be a very attractive fuel.

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Multi-Purpose Group

Continued confidence in the future was the keynote of Sir George Nelson's report to the shareholders of the English Electric Group of companies. Performance during 1956 proved to have been very satisfactory. Profits increased by 6½ per cent., turnover by about 4 per cent. and orders booked rose by 19 per cent. to £180 million. This was the result of activities in a very wide field, including steam turbines, atomic power plant, Diesel engines, transformers, switchgear, electric motors and control gear, domestic appliances, aircraft and aero engines, computers, instruments, radio and television transmitters, radar equipment, etc.

Performance has been far from equal in all these. The manufacture of aircraft, and of aircraft equipment and components, has

proceeded very satisfactorily. Demand for the Canberra has been high enough to warrant the manufacture of some machines at Short's in Belfast. The successful development of the P.1 fighter has resulted in "a considerable production order for early delivery." The progress made in the development of guided weapons was such that the company "can now reasonably claim to be in a position of major standing" both as designers and manufacturers. The development and manufacture of the Eland turbine propeller engine ensures that the group are represented in this field. The Eland is particularly suitable for the conversion of piston-engined aircraft to turbo-prop, and an adaptation of it is widely used as the power unit of helicopters. A free-turbine engine, the Gazelle, has also been developed for this use.

The group's activities in the rail-traction field have been less successful. Sir George said that capacity was under-employed and, referring to recent orders received from British Railways, that "we are in a position to undertake further substantial orders should we be called upon to do so." The same was true of capacity for the manufacture of consumer appliances, such as cookers, washing machines and refrigerators, in which very large sums have been invested. Output in the heavy electrical plant field appears to have been good (that of turbo-alternators rose by 12 per cent.) and prospects are satisfactory enough. Sir George's assessment of the future, as put to the shareholders of Marconi's Wireless Telegraph Company, summarises the general impression left after reading his three long reports: "We are very much alive to growing competition overseas, but with our wealth of research, development and production facilities, we can face the future with every confidence."

ENGINEER-PHYSICISTS APPLY NEW MATERIALS

Physical Society Exhibition, March 25 to 28

Exhibits that range alphabetically from "absorbing material" to "zoom lens," and that vary in complexity from a thermocouple to a general purpose computer, ensure that there is no lack of variety at the 41st Physical Society Exhibition. Held in the new and old halls of the Royal Horticultural Society, London, it will be open from March 25 to 28.

Considerable use of new materials is evident from the advance catalogue of the exhibition. Photoconductive cells and light amplifiers are among the items exhibited by the Research Laboratories of the General Electric Company, Limited, Wembley, Middlesex. The light amplifier is a series combination of a green-sensitive cadmium-sulphide crystal and a green electroluminescent layer. If positive light feedback is used a bistable device is obtained. Assemblies of such elements using only optical coupling could be envisaged for use in counter circuits and logical circuits.

Glass blocks, of densities ranging up to 6·1 grammes per cub. cm.—for protection against high energy radiation—and glass for gamma-ray spectroscopy are produced by Chance Brothers, Limited, Smethwick, 40, Birmingham. When a gamma-ray falls on the latter type and develops a soft shower in the glass, the incident energy is almost entirely dissipated in relativistic electron tracks. The tracks radiate a constant amount of Cerenkov light per unit length. A photo-multiplier viewing such radiation will produce a pulse proportional to the amount of electromagnetic energy incident on the glass.

ULTRASONIC TRANSDUCER

A memory matrix suitable for a transistor computer is demonstrated by the Plessey Company, Limited, Ilford, Essex. A compact information store is obtained by evaporating electrode systems on to single domain single crystals of barium titanate. A more conventional use for barium titanate has been as a transducer for ultrasonic generators. Its chief limitation is an inability to operate above 60 to 70 deg. C. and an electro-acoustic efficiency of not less than 20 per cent. A new material with an efficiency of not less than 50 per cent. is available and is displayed by Radio Heaters, Limited, Wokingham, Berkshire. It is a lead-titanate/lead-zirconate ceramic transducer that can be used up to 300 deg. C. without depolarisation. Also, unlike barium titanate, the new material regains its polarisation—should it be accidentally overheated—on cooling. It is also claimed that the zirconate material can work at loadings of 50 watts per sq. cm. as against 10 watts per sq. cm. for barium titanate.

Semi-conductors and ferrites appear in various applications. A transistorised ferrite store is exhibited by Standard Telephones and Cables, Limited, Aldwych, London, W.C.2. A drilled ferrite block is substituted for individual ferrite cores, and reading and writing access waveforms are derived from transistor circuits. Output signals are amplified by transistor pulse-amplifiers and fed into a simple transistorised logical circuit. The use of a nickel zinc ferrite tube as a vibrating element for a highly selective band-pass filter is demonstrated by Mullard, Limited, Torrington-place, London, W.C.1. Two valve oscillators using similar elements are also on display. One uses an element oscillating at about 85 kc/s in a torsional mode. The other has an element oscillating at about 135 kc/s in an extensional mode. The same firm is showing a number of instruments employing transistors, notably an oscilloscope with a bandwidth greater than 300 kc s and a counter which has a resolution time that is better than a microsecond.

Materials for high temperature applications are among the exhibits displayed by the Plessey Company, Limited. A combination of two distinct materials, one electrically conductive and the other insulating at high temperatures (capable of being bonded together to give a hermetic seal) forms the basis of a series of electrical components. Plug and socket connectors, lead-through insulators, etc., are possible for temperatures up to 500 deg. C. In one instance pressure differentials of 1,000 lb. per sq. in. may be withstood.

URANIUM REFINING

Instruments for atomic energy applications are represented though not to the extent that might be expected. Ericsson Telephones Limited, New Basford, Nottingham, are demonstrating a type of reactor control channel that maintains reactor power at the level of demand. Ekco Electronics, Limited, Southend-on-Sea, Essex, are displaying a sample rack of equipment for reactor instrumentation. The rack contains a reactor period meter, a fast-neutron monitor, a power error unit and a power error test unit.

Problems in reactor engineering often involve first-order linear differential equations because of the presence of simple exponential processes. Such problems are readily solved by analogue techniques. A typical application is demonstrated on the stand of Elliott Brothers, Lewisham, London, S.E.13. A general-purpose analogue computer is shown working on a study of power levels in a nuclear reactor. The system consists of six neutron sources, and may be described by seven-first order differential equations. One of the equations contains a non-constant coefficient, the product term being obtained by a means of a servo-multiplier.

Several automatic chemical processes are shown, including an analyser for uranium producing plant. Uranium refining is commonly achieved by an ion-exchange process in which the uranium is absorbed in a resin column. When the resin ceases to absorb, valuable material gets wasted. Rapid chemical analysis of column effluents will indicate the failure of the absorption process. But a large number of such analyses are required to monitor a continuous process employing several columns. An automatic process, the Analmatic uranium analyser, is demonstrated by Baird and Tatlock, Limited, St. Cross-street, London, E.C.1. Sixteen process streams are continually monitored. An "excess concentration" alarm is given when the uranium concentration exceeds an adjustable preset limit. Contemporary batch samples are taken in cyclic order and treated with aqueous ammonium thiocyanate. A reducing agent is also added, to suppress interfering ions, and the resulting colour complexes are analysed by an absorptiometer at 3,650 Å. The cycle of events is entirely automatic and a permanent record of the uranium concentrations in individual streams is produced.

The growing use of radioactive isotopes is apparent. A number of thickness gauges are displayed that rely on beta radiation for their operation. The use of bremsstrahlung radiation to extend the upper limit of the beta thickness gauge is demonstrated in the "Atomat" nucleonic thickness gauge, manufactured by Baldwin Instruments Company, Limited, Dartford, Kent. The gauge is for use on cold strip rolling mills. An experimental profile gauge for the measurement and recording of the profile of continuously extruded tube is demonstrated by Isotope Developments, Limited, Aldermaston Wharf, Reading, Berks. A beta-ray shadow technique is used and measurement is independent of transverse movement up to $\frac{3}{4}$ in.

MINIATURE MICROSCOPE

Atomic energy, television, and computers all employ a variety of pulse techniques and many firms are displaying instruments for pulse generation and pulse analysis. An instrument designed to measure the amplitude distribution of the pulses produced by any type of nuclear-particle detector will be shown by Philips Electrical, Limited, Shaftesbury-avenue, London, W.C.2. The analyser, type 1438B, will be shown operating in conjunction with a scintillation head, and displaying the energy spectrum of caesium 137. A pulse generator that produces pulse widths from 0·05 microsecond to 1·0 microsecond will be shown by E.M.I. Electronics, Limited, Hayes, Middlesex. Repetitive or single shot operation is possible. The pulse rise time is approximately 10 millimicroseconds.

The electronic field is not the only one in which miniaturisation is taking place. McArthur Microscopes, Limited (Dr. J. McArthur), 101 Chiltern-court, London, N.W.1, have introduced a new form of microscope. It is a rigid block of metal measuring 4 in. by 2½ in. by 2 in. Three standard objectives are carried—achromats, fluorites, or apochromats—with magnifications from × 24 to × 1,500. A standard eyepiece is used and conventional illumination. Proper tube length is provided by a prismatic system. The instrument is easily carried in the pocket and may be used in the hand at the highest powers. It is suitable for work under rigorous field conditions.

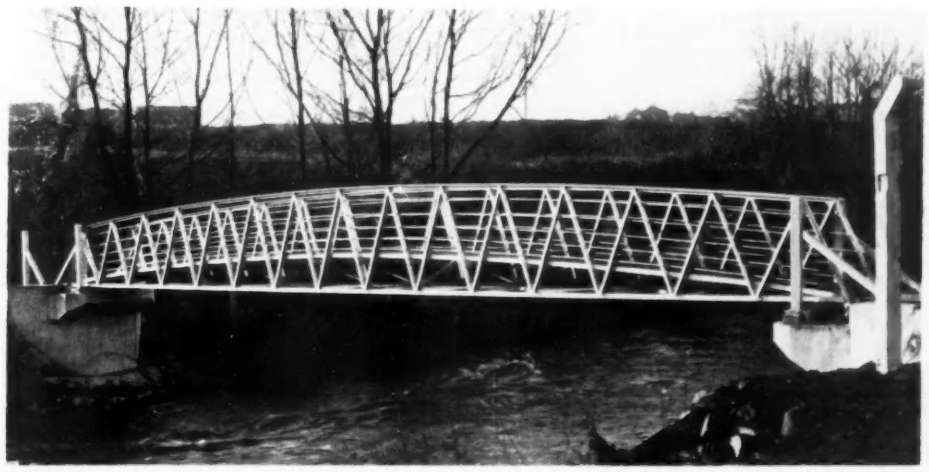
An unusual use of the B.B.C. Light Programme is envisaged by Furzehill Laboratories, Limited, 57 Clarendon-road, Watford, Hertfordshire. The 200 kc/s Droitwich transmission is used to drive a trigger circuit providing output pulses at carrier frequency. With a pulse repetition frequency as accurate as that of the 200 kc/s carrier (1 part in 10^8) the unit provides an economical means of frequency or time measurement.

Illustrated descriptions of some of the exhibits at the Physical Society Exhibition will be published in a future issue.

WELDED ALUMINIUM FOOTBRIDGE

Shown in the accompanying illustration is an aluminium footbridge that has recently been completed for the Northern Aluminium Company, Limited, Banbury, over the River Ebbw, between the South Wales towns of Rogerstone and Bassaleg. The bridge, which is of 60 ft. span, is one of the first examples of all-welded fabrication for a structure of this type.

The approaches carrying the pathway were limited to a gradient of 1 in 10, and the bridge was required to have a clearance, above the highest water mark, of 3 ft. These conditions meant that, if the approaches were not to be unduly long, the bottom chord of the bridge girders could not be lower than the points of support on each bank; this allowed little depth for bracing.



This 60 ft. aluminium alloy footbridge is one of the first examples of all-welded construction for this type of structure. The natural corrosion-resistance of the alloy enables it to be left unpainted.

The bridge is of through-type W-latticed girder construction, the top chord of each girder serving as a handrail. This top chord is curved to a radius of 226 ft., the depth of girder being 4 ft. 6 in. at the ends, and 6 ft. 3 in. at midspan. The 4 ft. 6 in.-wide footway is similarly curved to give a 4 ft. 6 in. handrail height throughout. All the essential lateral rigidity is provided by transverse and diagonal bracing, in both horizontal and oblique planes, below the level of the flooring.

The bridge was designed for a live load of 100 lb. per sq. ft. (on a 15 lb. per sq. ft. dead load), with provision for a point load of 500 lb. Lateral design loadings were 50 lb. per ft. run on the handrail, and a wind load of 12 lb. per sq. ft. The bridge is in a reasonably sheltered position.

In order to use the structural material to best advantage, maximum use was made of bulbed and lipped extruded sections. The bottom chord of each bridge girder is a 4 in. by 3 in. by $\frac{1}{4}$ in. extruded T, and the top chord and handrail a T with its flanges radiused and bulbed to provide a comfortable hand-grip. Lattice members are of $3\frac{1}{2}$ in. by $1\frac{3}{4}$ in. lipped channel section, and bracing members of $1\frac{3}{4}$ in. equal bulbed angle. The alloy chosen for all structural parts was Noral B51S (B.S. 1476: HE30), fully heat-treated. In this condition, this alloy has a guaranteed proof stress of 16 tons per sq. in.; it has a high resistance to atmospheric attack, and has come to be recognised as the most suitable aluminium alloy for normal structural applications.

In welding a heat-treated aluminium alloy such as HE30, there is an inevitable local reduction of properties close to the weld though, after welding, the quenching effect of the adjacent metal usually brings about a partial recovery of strength. By avoiding transverse welds, the local loss of strength can be minimised; in this footbridge the usual practice of making use of gusset plates at joints was also adopted. All welding was carried out with Argonaut shielded-arc equipment.

The flooring consists of Noral corrugated aluminium sheeting of the deep-ridged "Industrial" pattern, 14 s.w.g., with the corrugations placed transversely. The sheets are carried on two longitudinal 3 in. by 2 in. by $\frac{1}{16}$ in. plain angle sections welded to the lattice members, and are secured with aluminium rivets. The footway itself was made by laying about a ton of bituminous road material over the corrugated sheeting.

To reduce the spaces in the girders (to prevent a child, for example, falling through the side of the bridge) five 1 in. diameter aluminium tubes, the full length of the bridge, pass through the lattice members. Each tube is secured by welding only at each end of the bridge (where the handrails turn over to form the end posts), passing through clearance holes in the intermediate members.

The bridge, which was designed for Northern Aluminium Company, Limited, by Aluminium Laboratories, Geneva, was fabricated by the Atlantic Shipbuilding Company, Limited, at Newport. The complete structure (approximately 2,100 lb. without the bituminous decking) was transported to site by road, and launched with the help of two mobile cranes. At its points of support the bridge is carried on pin-joints, a link being provided at one end to allow for thermal expansion. When complete, the whole aluminium structure was left in its natural state, without painting or other protection. The fact that no painting will probably be required during its lifetime was, of course, one of the major factors leading to the choice of aluminium for its construction.

* * *

CHEMICAL TANK AND STAND OF STRUCTURAL PLASTICS

A rather striking example of the application of a compound laminate as a structural material in the chemical-engineering industry is shown in the accompanying illustration which depicts a large storage tank and stand completed recently by Mendip (Chemical Engineering), Limited, Feltham-road, Ashford, Middlesex. Both the tank and the stand are made from Bakelite Limited epoxide and polyester resins reinforced with glass-fibre materials. The tank measures 8 ft. by 4 ft. by 6 ft. and is designed to accommodate the highly corrosive chemical, zinc chloride, to be used by the Ever Ready Company (Great Britain), Limited, in the manufacture of electric batteries.

When full the tank weighs 10 tons. The stand itself is 10 ft. in height and is a properly stressed engineering structure. The good inherent rigidity of the main supports, as will be seen, are further enhanced by cross members.

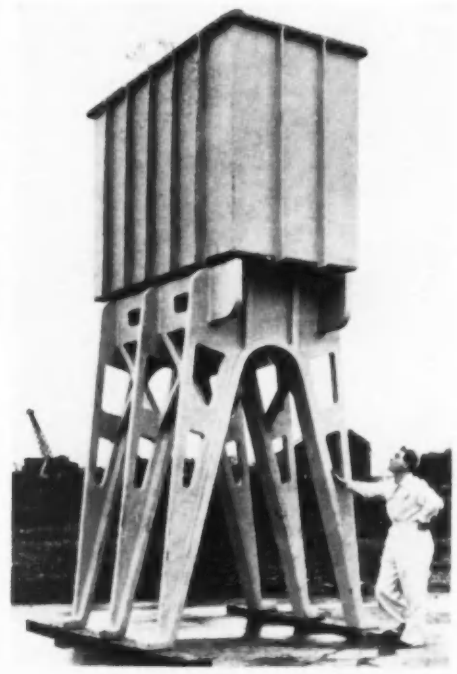
* * *

EQUIPMENT FOR CUTTING AND WELDING

Information has recently been received from the Union Carbide International Company, 30 East 42nd-street, New York 17, N.Y., U.S.A., of several new additions to their range of equipment. The items mentioned include welding and cutting outfits designed especially for production welding and the limited cutting of light gauge metals in aircraft and small parts manufactures, and for general repair and maintenance operations. They include the Purox W.200 blow pipe and the CW200 cutting attachment. The latter adapts the blow pipe for cutting iron and steel up to 2 in. thick. There is also a new line of Union-Melt welding heads and assemblies for submerged arc welding which are similar to the older apparatus but have greater adaptability. There are three models, one of which uses electronic voltage control, one electronic speed control for constant potential welding and the third standard arc voltage control. The first feeds wire up to $\frac{1}{16}$ in. diameter at currents up to 2,000 amperes, and the other two accommodate wire up to $\frac{1}{4}$ in. diameter and currents up to 1,200 amperes. All three can be used with existing controls and carriages.

For use with welding equipment is Anti-Spatter, an emulsion containing silicones, which when spread by brush or fog spray over the area surrounding a weld prevents the adhesion of particles of weld metal. In this way, the surroundings can be wiped clean with a cloth after welding. The material is odourless and non-inflammable, and has a lasting time of some weeks. No special post-treatment is required when the surface has to be painted.

Flame plating is a process developed by the



A 10 ton tank on a stand 10 ft. high, both made of compound laminates of epoxide and polyester resins reinforced with glass-fibre materials. The tank is to hold zinc chloride used in the manufacture of electric batteries.

company for increasing the wear life of dies. It consists of depositing a thin coating of tungsten carbide or aluminium oxide on metal surfaces by means of controlled detonation. Since the temperature on the surface being plated is only 400 deg. F., there is little danger of dimensional or metallurgical change in the part being plated. After deposition the surface can be finished to a smoothness of 0·5 micro inches r.m.s. It is claimed for this method that it reduces costs and also eliminates pick-up from the work-piece on the dies.

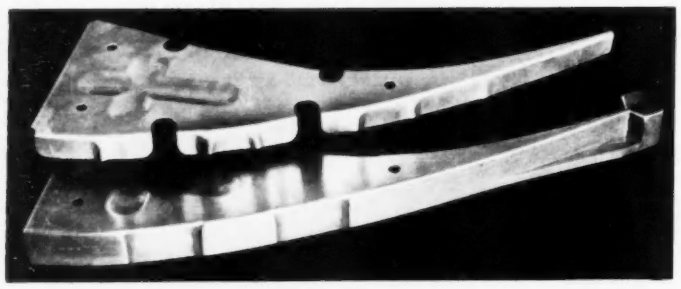
IMPROVED RUBBER PRESS TECHNIQUE

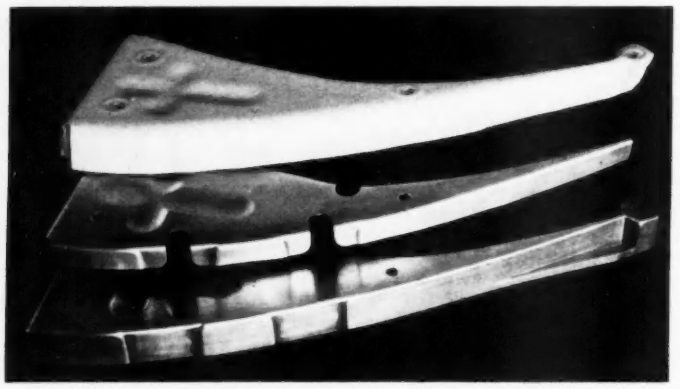
Thermoplastic (P.V.C.) Intensifiers

In the manufacture of light-alloy parts for British military aircraft and for wing-tip metal drop tanks, Short Brothers and Harland, Limited, Queen's Island, Belfast, have introduced a new process, which involves the use of a sheet of thermoplastic material (polyvinyl chloride) to intensify the pressure exerted by the conventional rubber press, thereby substantially reducing the time normally taken by hand-finishing. One operation which formerly took 72 minutes is now being completed in 2 minutes, and in other cases time savings of more than 20 minutes have been gained.

The P.V.C. intensifier is inserted between the rubber press and the alloy components being produced. Whereas the rubber is inclined to follow the contours of any wrinkles, the harder intensifier irons them out without scoring or damaging the part. This applies particularly to intricate flanged parts where the pressure of the rubber press tends to decrease as the flange angle of the component alters, as may be seen from the accompanying illustrations, which show a 26 s.w.g. flanged component formed on the rubber press with and without the use of the intensifier. It will be seen that the workpiece formed with the intensifier is free from the pronounced flange wrinkles resulting from the conventional rubber-pressing technique.

Hand-finishing, though not completely eliminated, is substantially reduced by this method. The saving in labour costs far exceeds the outlay on the material and manufacture of the intensifiers.





(Above) A 26 s.w.g. component, with the die on which it was formed by the conventional rubber press method. The pronounced flange wrinkling on the component will require considerable hand adjustment.

(Right) A similar component, with die and P.V.C. intensifier. The use of the intensifier during press forming has completely eliminated flange wrinkling.

FLUID BED HEAT-TRANSFER FOR TEXTILES

Six commercial firms have formed a co-operative group to develop, manufacture and market a new textile processing technique developed by the British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester, 22. The new technique utilises a fluid bed which is a very efficient means for conveying heat and is therefore of great potential value in textile processes involving heat transfer.

While cloth is being processed it may be wetted and dried several times. Thus, cleaning, dyeing, and various forms of finishing all involve wetting the fabric and, in fact, the textile industry is among the largest users of fuel for drying, the consequence being that the industry's fuel bills are considerable.

The fluid bed now under development consists essentially of a column containing tiny particles through which air is blown. So far, very small glass beads called "ballotini" have been used and heaters are placed directly in the bed. It is pointed out that the control of the temperature is much more accurate than it is with conventional dryers. The temperature, moreover, is very uniform throughout the bed and the fabric, therefore, is dried evenly on both faces simultaneously.

It is claimed that fabric passed through the bed, from the bottom to the top, is dried four or five times more quickly than it is by any of the methods now used in the textile industry. Drying, dyeing and the baking, for example, of a crease-resistant finish on cloth can be carried out in a very short time. In fact, moisture can be dried off and the resin baked on in one operation taking about 20 seconds. In contrast, this kind of finish takes two operations at present, drying and baking lasting about 4 minutes.

Emphasis is laid on the fact that one of the greatest advantages of the fluid-bed technique is that it makes the dyeing of manufactured fibres an incomparably easier task than is now the case. So far, the only commercially-successful manner of dyeing fabrics like nylon and Terylene has been to impregnate the fibres with the dyestuffs under pressure in special vessels. This is an expensive batch process and each batch takes a relatively long time. The new heating medium, it is stated, makes it possible for the fluid bed to be used to dye nylon and Terylene in from 10 to 20 seconds and the process is continuous. Another important market for the rayon industry is tyre cords and it appears that latex-coated tyre cords can be processed in a fluid bed much more rapidly than by conventional methods. A further important application is in the fixing of printed designs on fabrics and tufted carpets.

To ensure that British industry obtains the maximum benefit, the British Rayon Research Association have taken out a group of patents covering various aspects of the new process in all the leading textile countries of the world.

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SOLID STATE OSCILLATOR

A new solid state device which will oscillate at microwave frequencies has been demonstrated by the Bell Telephone Laboratories, 463 West-street, New York 14. It is claimed that the device will also operate, in principle, as an amplifier. The chief advantage is, theoretically, a very low inherent noise level. The level predicted shows that receivers using this device would be about 200 times more sensitive than conventional types.

The device is composed of gadolinium ethyl sulphate—an ionically bound paramagnetic salt—diluted with an isomorphous diamagnetic substance, lanthium ethyl sulphate. The latter makes up about 99 per cent. of the finished crystal and reduces interaction between the gadolinium atoms.

Paramagnetic materials are characterised by an unpaired spinning electron. The electron may occupy three spin states of different energy —the lowest energy state being the most populated. When the crystal is irradiated with microwave power of a frequency corresponding to the energy change involved in the transition from state 1 to state 3, the populations of these two states become equal and power saturation occurs. Under such conditions the population of state 2 can exceed that of state 1. If another microwave signal is applied at a frequency corresponding to the state 2—state 1 transition, stimulated transitions occur. These give rise to radiation at the second frequency. Consequently a power gain is achieved at the second frequency. The Bell Telephone laboratories used 100 milliwatt at 17,500 Mc/s for the energising oscillation that produces power saturation. A self-sustained oscillation with a power of 20 microwatt occurred at 9,000 Mc/s.

The frequency of oscillation depends on the separation between the spin levels, which may be controlled by a magnetic field. For an oscillation of 9,000 Mc/s a field of 223,000 amperes per metre was necessary. The crystal was mounted in a waveguide cavity immersed in liquid helium at 1·2 deg. K. Low temperature operation is used so that power saturation of the crystal takes place with a reasonable amount of energising oscillator power. Also the temperature increases the population difference between the energy levels. The name "maser" has been coined to denote the principle by which the device works. The derivation is from the phrase "microwave amplication by stimulated emission of radiation."

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INFLATABLE REPAIR SHOP

A telegram has been received by Elliot Equipment, Limited, Llwynpia, Rhondda, South Wales, from Dr. Fuchs, leader of the British Antarctic Expedition, stating that the Numax inflatable hut supplied by the company is proving invaluable as a mobile vehicle-repair workshop, standing up to 30 knot winds and temperatures between − 4 deg. and + 20 deg. F., at Shackleton Base.

The Numax hut, it may be recalled, consists of tough Neoprene-coated fabric over an inflatable low-pressure framework. The detachable floor is also made of rubberised fabric.

In its packed form the hut is easily carried by two men and can be erected single-handed in 3 minutes on any terrain to a hut 30 ft. by 19 ft. by 9 ft. high.

ELECTRICAL EQUIPMENT FOR RECTIFIER LOCOMOTIVES

PRACTICAL AND THEORETICAL REQUIREMENTS

Two papers on rectifier locomotives were presented and discussed at a meeting of the Utilization Section of the Institution of Electrical Engineers on March 14. The first of these*, which was by Mr. H. B. Calverley, Mr. E. A. Jarvis and Mr. E. Williams, dealt with the electrical equipment, the principal items of which were the pantograph, circuit-breaker, transformer, on-load tap changer, rectifiers, smoothing reactor and direct-current traction motors. The transformer was needed to convert the 25 kV, 50 cycle alternating-current on the contact wire to a lower voltage for rectification. It was generally arranged for on-load tap-changing and thus formed the main method of control. Direct-current series motors were normally used and received their power from the rectifiers, which were connected to give a full-wave output voltage. Mercury-arc rectifiers of the multi-anode, ignitron and excitron types had all been used. Germanium and silicon rectifiers had also considerable possibilities. As the output of the rectifiers contained a large voltage of twice the line frequency, a reactor was connected in the direct-current circuit to limit the ripple current. The rectifier locomotive owed its superiority to its combining the best type of traction motor with the smallest and lightest type of converter.

TRACTION MOTOR CONNECTIONS

If all the traction motors were connected in parallel and were controlled by varying the voltage applied to them, the useful coefficient of adhesion was a maximum and no damage was caused by slip. The effect on the size and cost of the equipment as a whole might, however, be adverse. An important reduction in equipment could sometimes be made by connecting two motors permanently in series, thus reducing the total direct current and the number of reverser contacts and field-weakening switches. An equaliser connection between the pairs of motors could also be used to control the slip. Field-weakening was used on rectifier locomotives as an alternative to raising the transformer secondary voltage to increase the speed. To reduce the axle loads to a minimum it might be necessary to use six-pole rather than four-pole motors, thereby reducing the maximum voltage rating. The corresponding increase in current rating was a disadvantage for mercury-arc rectifiers and also for the control equipment.

The choice of rectifier connection—bridge or bi-phase—was determined by the voltage in the direct-current circuit, particularly with mercury-arc rectifiers. There would be some cases where the power output could be handled by two rectifiers in bi-phase, where four would be required in bridge. Irrespective of voltage and the number of rectifiers, the bridge connection, however, resulted in a transformer of lower rated mean apparent power for a given direct-current output. The weight and volume of a transformer were also approximately proportional to the mean apparent power. By using a three-wire bridge circuit the voltages of two motors in series were as well stabilised as if they were in parallel, the rectifiers gave their full output and the apparent power was reduced to a minimum.

CONTROL OF MOTOR VOLTAGE

The motor voltage was controlled by on-load tap-changing or stepless systems. With the former some type of impedance was introduced into the commutating circuit of the rectifiers to ensure that the tap-changing did not cause a momentary short-circuit across a portion of the transformer winding. Both high and low voltage control could be used, each of which had advantages and disadvantages, and the method adopted had an important bearing on the transformer rating. Other factors for consideration were the type of rectifier connection, whether or not dual-voltage operation was adopted and, in the case of high-voltage tap-changing, the maximum voltage to earth for which the tap-changer was suitable.

Two basic methods of stepless control were possible—by using induction regulators or regulating transformers, or by employing firing delay on the rectifiers.

EQUIPMENT DESIGN AND OPERATION

The transformer was the heaviest item of equipment on the locomotive and it was therefore worth while considering every means of attaining the minimum weight. With this end in view it was customary to use a current density several times greater than for a conventional substation transformer with correspondingly higher copper losses. To disperse these losses forced oil circulation must be used. This necessitated a large radiator and additional weight.

The core was built up from laminations of grain-oriented silicon-iron alloy, which could be operated at flux densities near to saturation without excessive losses on magnetising current. This reduced the weight appreciably. On high-voltage control systems the rectifier transformer and the auto-transformer had a common yoke. This only carried the difference in flux of the two transformers, so that the iron section was reduced with a corresponding decrease in weight. The shell type was usually preferred.

Fully mechanical, fully electrical and combined mechanical and electrical schemes for controlling the voltage had been proposed. An example of the last comprised mechanically interlocked selector contacts with pneumatically operated load switches. The advantages of this arrangement were that mechanical interlocking was provided between those contacts for which correct sequence was vital; during the run-back of the tap changer after the power had been shut off, repeated rupture of the circulating current was avoided; notching-back could be made reasonably simple; and the load switches could be used for clearing faults or for back-up protection.

RECTIFIER CHARACTERISTICS

With mercury-arc rectifiers there was a choice between air and water cooling, between the single and multi-anode types, and, with the single anode type, between ignitrons and excitrons. The multi-anode rectifier was not as convenient as the single-anode rectifier on account of its size and shape and of the desire to use bridge circuits. Assuming six-pole motors, the continuous current rating required at between 600 and 900 volts was from 1,100 to 750 amperes. These ratings could be conveniently obtained with small rectifiers by the use of water cooling, the water being heated up when starting in cold weather, as it was essential to avoid applications of load at too low a temperature when "ion starvation" would cause voltage surges.

The water-cooled ignitron had been used almost exclusively and had given good results. Its drawbacks were the complicated firing circuits and the limited life of each ignitor compared with that of the rectifier as a whole. For that reason two or three ignitors were usually fitted in each rectifier. These drawbacks were overcome in the excitron, but this type of rectifier needed a cathode insulator and an ignition device, both of which added to its weight. The more straightforward method of operating the excitron auxiliaries was in its favour, but the rectifier construction was more complex. Whatever rectifier was used it must be pumpless.

Semi-conductor rectifiers were being rapidly developed and had a promising future for traction. Their greatest asset was simplicity, owing to the absence of pre-heating, excitation and ignitron equipment. A set of semi-conductor rectifiers was more flexible in dimensions than a mercury arc rectifier.

RIPPLE EFFECTS

The output of the rectifier contained voltages of all the even harmonics, and the magnitudes of the resulting alternating currents depended on these and on the total circuit impedance. The harmful effects of the ripple could be reduced by increasing the size of the smoothing reactor included in the circuit, but a compromise was necessary as reactors were heavy, one rated at 800 amperes weighing ½ ton. A ripple of between 30 per cent. and 50 per cent. must therefore be allowed to achieve minimum weight.

Excessive heating due to ripple occurred in the main and interpole field windings unless they were designed for minimum eddy current and stray losses. Satisfactory commutation, too, was not so easily obtained as with a steady current, owing to the circulating currents in the brushes caused by the "transformer" electromotive force and owing to the interpole flux not following the pulsations of the armature current correctly in magnitude and phase. Nevertheless, standard direct-current traction motors were performing very well on pulsating current. Moreover, a rectifier-fed motor should be less susceptible to flash-over.

If a non-inductive resistor of, say, 10 times the field circuit resistance were connected across the main motor field, most of the ripple current would flow through it and the pulsation of the main flux would be reduced by about 80 per cent. Thus, the self-induced voltages between the commutator bars and in the armature conductors would be much reduced and the pulsation of the voltage of rotation decreased as far as the main field winding was concerned. On certain motors there was also an improvement in commutation.

In discussing the characteristics of the equipment the authors contended that no ideal solution had yet been found as the development potential was too great for any existing designs to be regarded as final.

CIRCUIT CALCULATIONS

In the second paper*, which was presented by Mr. T. E. Calverley and Mr. D. G. Taylor, the authors pointed out that the increasing use of rectifier locomotives and motor coaches had focussed attention on the limitations of accepted theory in the calculation of the performance of bi-phase and single-phase bridge-connected rectifier circuits. Most industrial installations exceeding a few kilowatts in rating were supplied from a three-phase system and were designed to operate with six or twelve-phase output on the direct current side. In these equipments the ripple current, which was associated with undulations in the output voltage, was imposed on the direct current, but for the purposes of calculation was sufficiently small for it to be assumed that the direct-current circuit had infinite inductance. Although this assumption led to considerable simplification of the theory, it was not tenable in such equipment as that used on the Lancaster-Morecambe-Heysham line, as it had been found that the presence of ripple current in the direct-current circuit had a profound effect on the operation of the whole equipment.

Solutions, which were described in the paper, could, however, be obtained to both transient and steady state problems by taking account of the resistances, inductances and capacitances in all parts of the circuit. Equilibrium equations were established in terms of mesh current and expressed as simultaneous first-order differential equations. These equations were solved by the Deuce digital electronic computer and were supported by tests on the Lancaster-Morecambe-Heysham line.

* "Electrical Equipment for Rectifier Locomotives."

* "Circuit Calculations for Rectifier Locomotives and Motor Coaches."

EFFICIENCY AND HEALTH OF DRAUGHTSMEN

INFLUENCE OF DRAFTING EQUIPMENT

The shortage of draughtsmen to-day is only too well known. In order to attract the labour and skill which is in such great demand, much can be done by providing drawing offices with equipment which will lessen the physical work involved in the designer expressing his thoughts on paper, and allow more time for creative thought.

Tests have recently been carried out by the Battelle Institute and others which have sought to find out what effect various types of equipment have on the working capacity and health of draughtsmen. The equipment used varied from a T-square and set squares on a horizontal board, to a drafting machine with an adjustable zero head on an upright adjustable board. Test drawings included a simple engine part, an architectural drawing and a fairly difficult assembly drawing with main groups arranged about centre-lines inclined at various angles. To ensure comparable conditions, the equipment was interchanged between the draughtsmen and, to create a measuring standard, the time taken to produce the drawings was estimated by the average time taken by other draughtsmen using standard drafting machines at upright adjustable boards. In Table I below, this time is expressed as 100 per cent. The times taken to produce the same drawing using various equipment are shown in the other columns.

The test on the simple drawing readily showed the advantage of the drafting machine with an upright adjustable board as compared with other means. Figs. 1 and 2 give a clue as to why this is so, as the number of hand movements necessary to complete the triangle with T-square and set squares is far greater than with the aid of a drafting machine. The reduction of fatigue due to board position is reflected in the fact that the test was completed more quickly with the parallel-motion unit at an upright board than with a drafting machine on a horizontal board, indicating the importance of board position.

The test on the complicated drawing proved that the drafting machine with a zero head on an upright adjustable board was the most suitable equipment from the aspect of speedy working, thus reducing fatigue.

The importance of working posture has long been accepted as an influence on health and efficiency. The dictum that "A comfortable workman is a safe workman" is very true in the workshop, but in the drawing office it could well be translated "A comfortable draughtsman is a speedy and accurate draughtsman." Many draughtsmen spend much of their working time in bad postures due largely to the bad design of the equipment they use. Further tests were carried out on the effect of working positions on the health of draughtsmen. Some typical positions are shown in Figs. 3 to 6. Interviews with 300 draughtsmen using various types of equipment at various working positions produced information on the causes of common complaints which are a significant indication of the importance of working positions. Table II below records the percentage of those interviewed who stated that they suffered from the ailments listed.

It can be seen that, comparing the best and the worst mean values, leaning over a horizontal board can produce twice the number of complaints suffered by those who stand at an upright board.

The French Ministry of Education set up a fact-finding committee to investigate the causes of absenteeism in Government departments, the results of which were published in *Annales d'Hygiene*. It was found that working at a horizontal board ". . . inevitably results in deformation of bone structures, and in most cases results in painful disturbances of the digestive organs; . . . compression of the thorax (when stooping or leaning over a board) can also cause considerable functional complaints in the respiratory organs, since sound respiration is inhibited and vitally reduced."

These various tests and reports show that, to achieve maximum efficiency, the draughtsman must be provided with equipment which promotes comfortable working at all points of the drawing board, with the minimum hand movement, and also provides facilities for changing his position without loss of efficiency.

Given this equipment in the form of modern drafting machines, output, accuracy and health

TABLE I Comparative Times for Preparing Drawings Using Different Equipments

—	Standard drafting machine on upright adjustable board	Drafting machine with adjustable zero head on upright adjustable board	Counterbalanced parallel motion and set squares on upright adjustable board	Standard drafting machine on a horizontal board	Counterbalanced parallel motion and set squares on a horizontal board	T-square and set squares on a horizontal board
Simple sketch ..	100	100	115	120	130	130
Complicated drawing ..	100	84	125	130	140	150
Mean	100	92	120	125	135	140

TABLE II *Relationship of Posture and Ailments Suffered by Draughtsmen*

—	Horizontal Board		Upright Adjustable Board	
	Sitting	Standing	Sitting	Standing
Headache ..	52	47	36	31
Bronchitis, colds ..	38	59	29	21
Constipation ..	29	44	22	14
Backaches ..	14	50	24	14
Foot complaints	10	31	18	27
Mean values ..	29	46	26	22

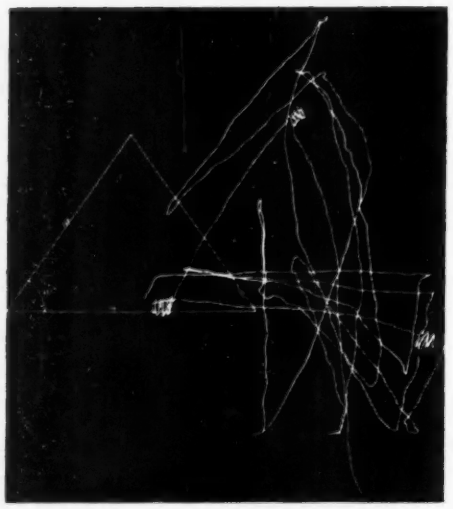


Fig. 1 Drawing a triangle with a T-square and set square. The diagram shows the movements of the right hand.

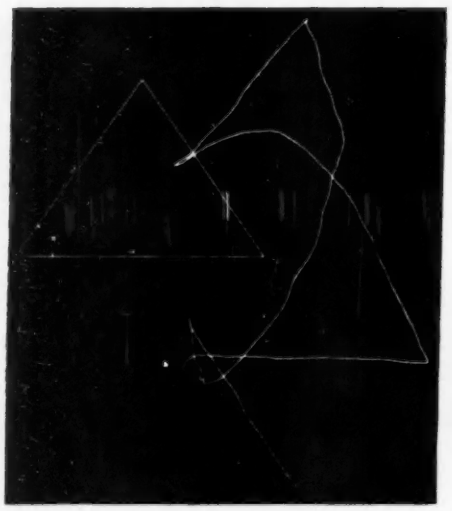


Fig. 2 With a drafting machine, the movements of the right hand while drawing a triangle are much reduced.

Fig. 3 In order to approach a correct viewing angle, the draughtsman is forced to take his off-balance weight on his arms if he is to maintain a stable working position when drawing at the top edge of a horizontal board.

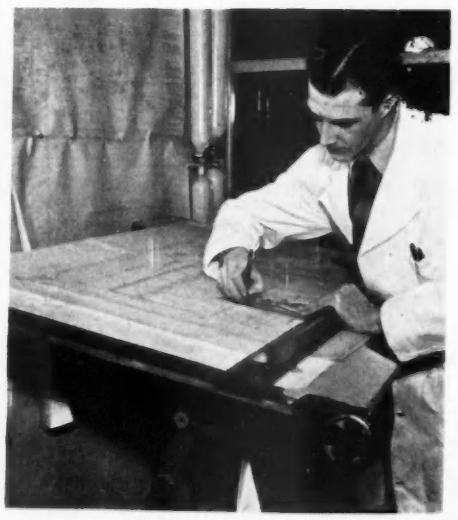


Fig. 4 When working at the lower edge of a horizontal board, to maintain a correct position and avoid the restriction of hand movement, the draughtsman must lean on the board edge and take his weight with his back muscles.

will improve. With the additional provisions of adequate lighting, congenial surroundings and a salary appropriate to their responsibilities, drawing offices should be able to attract all the men they need.

We are indebted to the Ozalid Company, Limited, 62 London Wall, London, E.C.2, for the information on which this article is based.

Fig. 5 Inclination of the board eases the draughtsman's stance, but unless the board is adjustable for height, the advantage will not be equal over the whole board area.

Fig. 6 With a fully adjustable drafting stand, the draughtsman can work high on the board from a seated position. His back is straight and his position relaxed. He is not off-balance and therefore no weight is thrown on his arms and no strain is placed on his back muscles.

★ ★ ★

The Lightfoot Refrigeration Company, Limited, Abbeydale-road, North Circular-road, Wembley, Middlesex, have designed a new range of high-speed single-acting Freon compressors, intended to give a high capacity per unit of floor space. The first of the range is a six-cylinder compressor with a maximum speed of 1,450 r.p.m. The bore and stroke are 2¼ in. and 2 in. respectively and the cylinders are arranged in three banks of two.

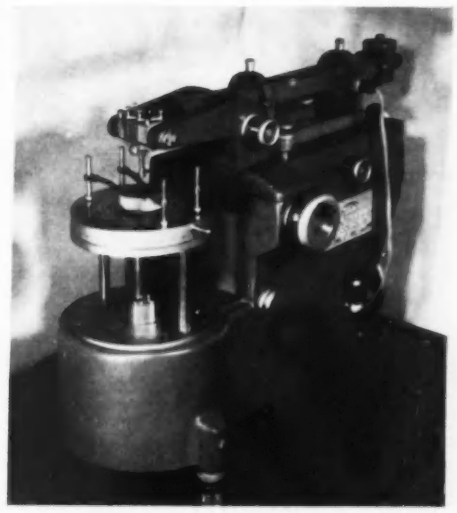
COMPARATOR FOR BORES UP TO 3 IN. DIAMETER

Accuracy to ± 0·000 01 *in.*

To meet a growing demand for an instrument capable of measuring the diameters of finely-ground or lapped bores to an accuracy of ± 0·000 01 in. or possibly finer, the Coventry Gauge and Tool Company, Limited, P.O. Box No. 39, Coventry, have introduced the N.P.L.-Matrix measuring machine. Built to a National Physical Laboratory design, the instrument operates as a comparator, using reference standards built up in box form from high-precision slip gauges and lapped end pieces, and will measure internal diameters from 0·1 in. to 3 in. It will work down to a bore depth of 1 in., and this figure can be doubled by reversing the bore, end for end, on the work table. A similar instrument is available for metric measurements.

The principal components of the instrument are a main casting, an elevating work table, and an adjustable slide, the latter carrying an autocollimator and a measuring head. The slide can be moved in a direction parallel with the axis of measurement, and also transversely, by means of two handwheels. A clamp enables it to be locked in any position. The worktable can be raised or lowered through a range of 6 in. by means of a handwheel, and it can also be locked by a clamp. The upper surface of the table can be rotated through 360 deg. by hand, and over a limited range at any position fine rotational adjustment is possible by handwheel. This fine adjustment enables the end faces of the reference standard to be squared and lined up with the measuring axis of the machine. Concentric circles marked on the surface of the worktable serve as a guide for approximate placing of the standard and the work, and a set of quick-acting clamps holds them in position. The edge of the work table is graduated at 5 deg. intervals as a guide to the orientation of the measurements made. A stem graduated at 0·05 in. intervals, and attached to the worktable, enables the axial depths of measurements to be ascertained.

The measuring head carries a double-ended stylus, mounted on a precision-pivoted arm on which there is a pair of optical reflecting mirrors. The stylus is about 0·05 in. shorter than the diameter of the bore which it is intended to measure, and it can be so set (by means of a small handwheel) that it contacts, with a very light pressure, each end of the diameter in turn. The mirrors are so mounted that they face the autocollimator and return to it images of its crosswire.



Measurement of bore diameters from 0·1 in. to 3 in., to a depth of 1 in., can be carried out on the N.P.L.-Matrix comparator, using slip gauges as reference standards.

On the autocollimator, which is a Watts instrument, one main division on the measuring drum corresponds with an angular displacement of the mirrors of one second of arc. The distance between the axis of rotation of the measuring head and the axis of the double-ended stylus is made equal to 2·062 in.; thus an angular displacement of the measuring head of one second of arc will cause the measuring contacts of the stylus to travel through a length of arc equal to 0·000 01 in. One second of arc is subtended by 0·000 00485 in. at a radius of 1 in. The autocollimator settings can be repeated to within 0·3 second of arc, and it is thus possible for the location of either end of the stylus to be determined to well within 0·000 005 in.

THREEPENCE A DAY FOR CRAFTSMEN

Since 1264 A.D. when building craftsmen were paid threepence per day and their labourers half this sum their wages have fluctuated—invariably upwards—until this year they appear likely to surge beyond the current 510*d.* and 444*d.* per day respectively. Up to 1914 the average annual rate of wage increase was about 0·8 per cent. per annum. In contrast, during the past four decades the increase has averaged 4·3 per cent. per annum, providing ample confirmation of the real advance in living standards and inflation. Two economic historians, Mr. E. N. Phelps Brown and Mr. S. V. Hopkins, in recent papers in *Economica*, discovered three principal features in the time long wage movement namely, the comparative absence of falling wage rates, their long periods of stability lasting sometimes 50 years, and this century a completely new development in the closure of the differential between the skilled and the unskilled, a contraction symptomatic of both the new social equality and the impact of mechanical aids on craftsmanship. The recent wages spiral has its more gentle example in Tudor times when the craftsman's wage after remaining steady at 6*d.* a day for a century rose in 1532 to double itself by 1580. In the nearer years between 1920 and 1933 wages dropped sharply by 30 per cent.

Throughout these seven centuries prices displayed quite different characteristics; oscillations over short periods and long years in which stability was almost absent reflected man's capricious struggle with Nature, coinage debasement and war. In the reign of Elizabeth I prices rose nearly fivefold. Much later the Napoleonic wars induced a period of inflation followed by a gradual decline in prices for the rest of the century. To-day prices are about 50 times those of the Thirteenth Century and wages about 170 times as much as they were. In real earning power the investigations have yielded some striking comparisons. The golden age of Henry VII was not again reached until 1880 and in the period between, during the reign of Elizabeth I, real earnings had fallen by about 75 per cent. The advance of 50 per cent. in this century has been the greatest achievement so far and it could be repeated comfortably by the Jubilee year of Elizabeth II in 1977; the question is—will it?

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BLOOM CUTTING

When the cropping shears used in a cogging mill to cut the white-hot blooms and billets to size had to be removed for overhaul, they were replaced by oxygen cutting blow-pipes, supplied by the British Oxygen Gases Limited, Gelderd-road, Leeds, 12. A track was laid down beside the roll table and on it travelled four bogies, each carrying a water-cooled channel-section boom which projected over the table. On the boom ran standard electrically driven torch tractors, connected by means of a tie rod to a small steel carriage on which was mounted the actual cutting blow-pipe. The apparatus is said to have given complete satisfaction.

MICROSCOPIC DUST

SAMPLING METHODS CAN AFFECT SIZE ESTIMATIONS

By A. J. Cruise

Possible relationships between concentrations of microscopic particles in both urban and industrial atmospheres, and respiratory diseases and disabilities, have led to a growing interest in the problems of airborne particulate matter. In this article the deposition patterns of dust particles are examined, and their effect on different sampling methods discussed.

In general it has been accepted that the human lung retains particles in the size range 0·5 to 5·0 microns. Evidence concerning the upper limit is somewhat unreliable as many investigators have reported the presence of much larger particles, and Boddy[1] shows a photomicrograph of a lung section containing a particle of 25 microns. Size analysis of dust from lungs shows that most of the particles are below the 5·0 micron limit however, and the main problem of estimating the concentration of respirable dust is that of collecting all these fine particles from the sampled air, and presenting them in such a manner that they can be accurately measured.

Conventional methods of counting or sizing particles assume that when viewed through the microscope system, they present their maximum projected diameter to the viewer. It will readily be appreciated that with irregular particles, orientation at the moment of deposition may prevent this maximum view being obtained. The wide variations in particle shapes will therefore permit them to offer at least three possible areas if they possess different dimensions of length, breadth, and thickness. Preliminary experiments in evaluating the effects of shapes upon the terminal velocities of particles suggested that variations in deposition patterns might be associated with different methods of sampling and collecting the particles.

In order to compare different methods of sampling, three types of instruments were set to sample a laboratory dust cloud generated in an enclosed space and allowed to drift very slowly past the sampling orifices. These were, therefore, substantially sampling the same cloud and were operated at low rates (approximately 6·0 cc. per minute) so that there was no tendency for the sampling rates to disturb the cloud. The instruments used included a thermal precipitator, a sedimentation cell where the particles are deposited vertically by gravity, and a horizontal sedimentation unit (after Boddy) where the particles settle out as a result of both vertical and horizontal movement.

The thermal precipitator operates by using a heated wire to produce a dust-free space in which the entering particles are repelled to collecting surfaces situated on each side of the wire and at suitable distances from it. Assessment of the particle sizes was carried out after the technique of Watson and Cruise[2] as this gives greater accuracy than conventional "counting," i.e., the estimation of the irregular shapes as circles of known area by comparison with a special eyepiece graticule. This usual method of comparison is only done on the surface of the particle in the optical plane of the microscope, and since the thickness of the particles lies along the optical axis, and is far greater than the depth of focus at high magnifications, it results in a two-dimensional "size." However, by shadowing the particles after collection on the microscope cover glasses in the sampling instruments, the third dimension is made visible in the same way as metal shadowing indicates thickness in the electron micrographs. Thus the approximate thickness of each particle can be calculated from the shadow length and the angle of shadowing.

ORIENTATION OF PARTICLES

Each particle was measured to ascertain the size of the containing rectangular prism surrounding it, and the nomenclature adopted was based upon that originally suggested by Heywood.[3] The plane view of the particle was measured to give the length L and the breadth B, and in each case L was made greater than B. The thickness T was calculated from the shadow length and this gave the prism L, B, T, containing the particle.

Under the conditions that prevailed all the particles deposited could be divided into three groups depending upon their orientation on the collecting surface. Group I contains all particles where $L > B > T$; group II those where $L > T > B$; and group III those where $T > L > B$.

Group I particles are considered to be in positions of maximum stability and therefore exhibit their maximum projected areas to the field of view. Group II particles are in a median position of stability, and group III in a position of minimum stability. This last group consists, of course, of particles viewed end on. Only the particles in group I can be counted or sized accurately by conventional methods, since in the other cases the areas available for comparison with the reference graticule will be smaller than the maximum projected areas.

Examination of the deposits showed that the pattern of deposition did vary with the sampling

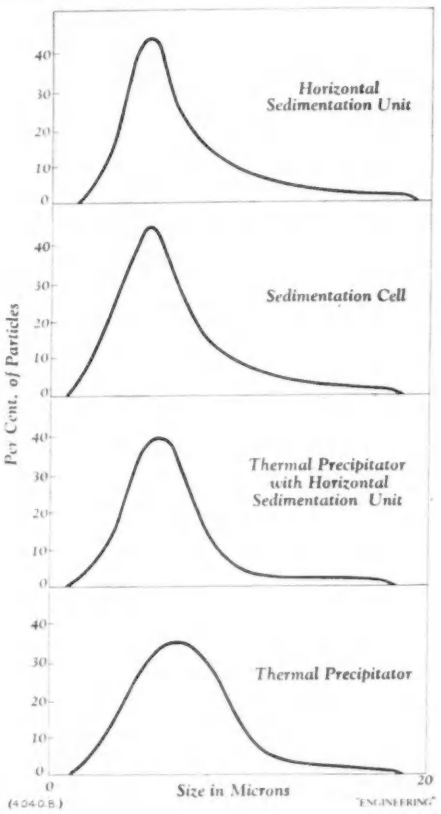

Fig. 2 Four different instruments sampling the same dust cloud show differences in size-frequency distributions.

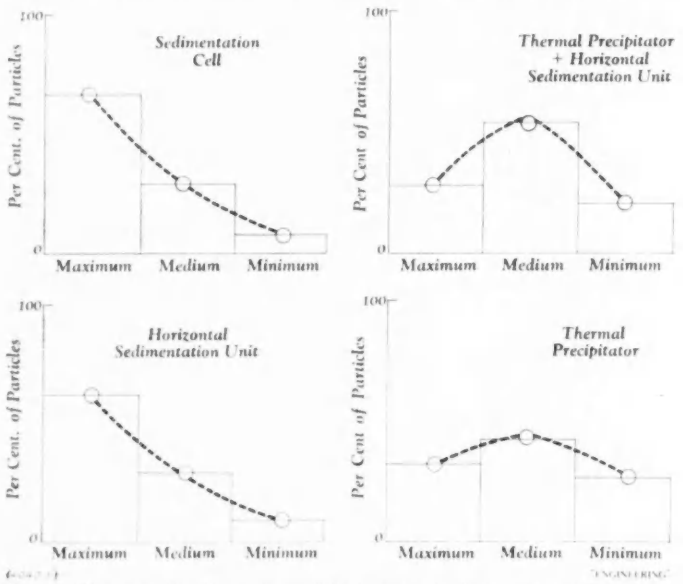

Fig. 1 The use of a thermal precipitator affects the position of stability in which the particles come to rest. The difference is enhanced when a horizontal sedimentation unit is placed before the precipitator.

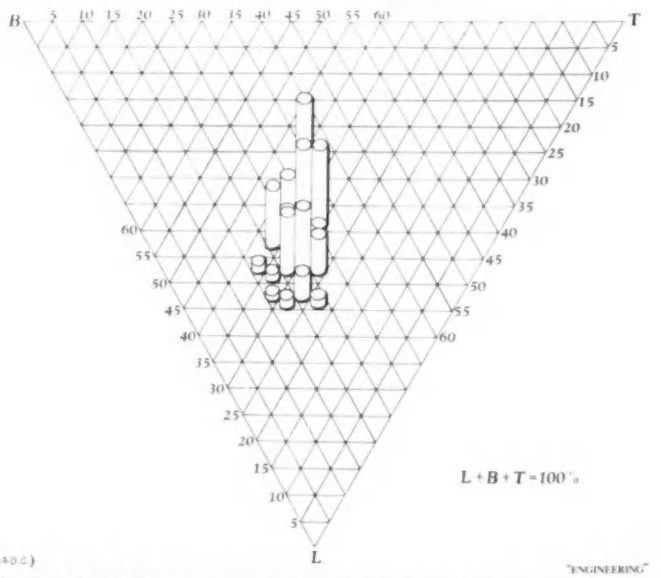

Fig. 3 Distribution of "shapes" of irregular particles arranged in the order L > B > T with L, B, T expressed as percentages. The bulk appear to be somewhat similar in shape.

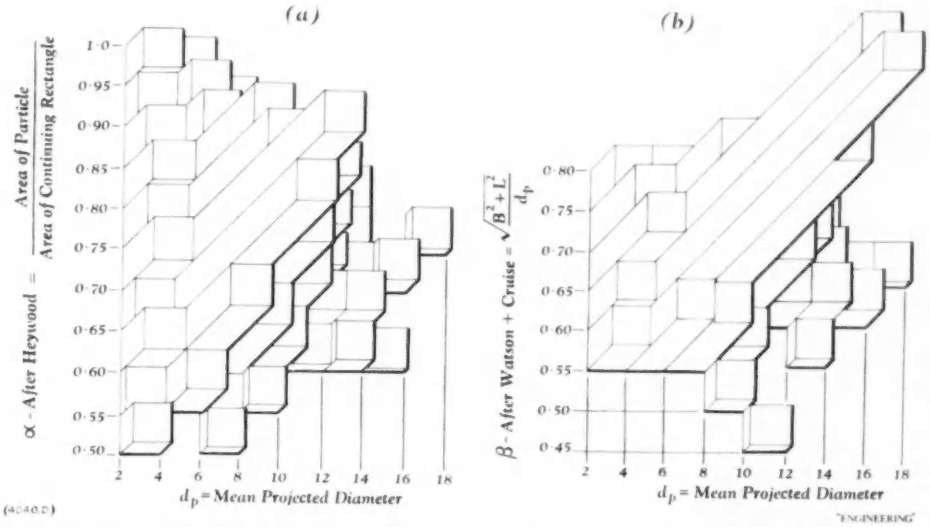
(a)
(b)
α - After Heywood = Area of Particle / Area of Continuing Rectangle
β - After Watson + Cruise = √(B²+L²) / d_p
d_p = Mean Projected Diameter
d_p = Mean Projected Diameter
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Fig. 4. Size and shape distributions obtained (a) after Heywood and (b) after Watson and Cruise.

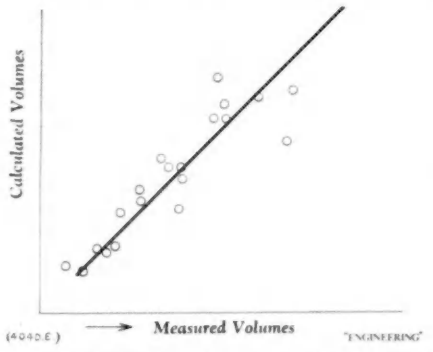

Fig. 5 Comparison between calculated and measured volumes of crushed particles.

method. Reference to Fig. 1 shows that the thermal precipitator influenced the deposition so that the numbers of particles in each of the three positions is roughly the same. In the other instruments there is a much higher proportion of particles in the stable positions and a lower proportion in the unstable positions. In fact these instruments follow the type of deposition which would be postulated on *a priori* grounds. The bulk of the particles would tend to assume stable positions on settling, and fewer and fewer would tend to take up the remaining unstable positions. C. N. Davies[4] has suggested that particles at low Reynolds numbers in viscous flow may not orientate themselves with the direction of flow, and that such orientation only occurs at high Reynolds numbers. In view of the differences in these deposition patterns where the particles have been exposed to both laminar-horizontal flow, and vertical sedimentation at low Reynolds numbers, it is possible that the act of settling-out orientates the particles on the collecting surface.

The difference in the pattern of the thermal precipitator may therefore be due to one of two causes. Firstly, if the particles are in random orientation in the cloud, they may be deposited in a random manner. Secondly, if, in fact they are orientated in the cloud, the operation of the intrument may influence their deposition. In considering these two possibilities it can be shown that there is one structural feature of this instrument which could account for this type of deposition. In a thermal precipitator the collecting surfaces are vertical glass microscope coverslips. They are situated on each side of the wire, and as the particles are repelled towards them it is likely that they are moving sideways to the main air flow. If the particles are orientated in the air stream to present their maximum projected areas normal to the direction of flow, then any sideways motion will result in the particles being deposited in a position of median stability. Thus these particles are in effect presenting a "side elevation" to the microscope when viewed. It will be observed from Fig. 1 that the number of particles in this position when sampling with this instrument is greater than those in the other positions.

Furthermore, when a horizontal sedimentation unit was placed before the sampling orifice of the thermal precipitator, the number of particles in the position of median stability increased still further. This suggests that horizontal sedimentation tends to arrange the particle orientation along the flow lines so that maximum projected areas are observed, and that the thermal precipitator tends to bias the deposition pattern in favour of collection in median stable positions. Under these conditions particles deposited in the thermal precipitator will tend to be "undersized," and, as this will operate over the whole of the size-range present, size frequency distributions may tend to have broad peaks. Fig. 2 shows the size frequency distributions of the particles assessed on maximum projected areas. That of the thermal precipitator is noticeably different from distributions obtained by the use of the other instruments.

SHAPE RELATIONSHIPS

Having established the major dimensions of the particles, the results were examined to ascertain if any general relationship existed in the three-dimensional shapes exhibited by them. Considering shape *per se* and neglecting size, it was possible to arrange the particles according to their proportions of L, B and T. The results were plotted in Fig. 3 by taking $L + B + T = 100$, and expressing the values of L, B, T, as percentages. While there is some scatter about the main positions, the results suggest that, as far as this sample of coal dust is concerned, the bulk of the particles are somewhat similar in shape. The scatter is noticeably less than that shown by shape factors based upon the usual dimensions measured. Fig. 4 indicates the size and shape frequency distributions based upon the factors α after Heywood and β after Watson and Cruise.

The knowledge of particle thickness gained by shadowing seemed to offer a possibility of estimating the aerodynamic diameter of the particles, i.e., the diameter of a sphere of equivalent terminal velocity. Squires and Squires,[5] in experiments with quartz particles in liquids, showed that in the case of flat discs, terminal velocities might be related to the diameter and thickness of the discs. They further suggested that this terminal velocity would depend to some extent upon the orientation of the discs. They derived an expression for variations of terminal velocity with thickness, and this method has been adapted to these particles of coal dust, but instead of using the thickness directly, an estimate of the exposed surface of the particle has been made. In considering the estimating of size by equating the irregular area of the particle, as observed, to that of an equivalent circle known as the maximum projected area, we are in fact "condensing" the irregular shape to a smaller dimension. If the same procedure is followed with the thickness it is possible to consider the particle as being condensed to a circular prism of diameter d and with a mean thickness t which is derived from the maximum thickness T. It has been shown (Watson and Cruise, *ibid*) that shape factors for two-dimensional views of particles are reasonably specific when particles are randomly orientated. The use of the "side views" obtained by the metal shadowing therefore, allows for a similar condensation to give a mean thickness.

Knowing the projected area of the particle and its mean thickness together with the measured irregular perimeter, the exposed surface may be calculated as $\frac{2\pi d^2}{4} + Pt$, where P is the perimeter, and t the mean thickness. This may be assumed to represent the external surface responsible for the drag on the falling particle. The effect of this drag in relation to size may then be used to derive a shape factor for the three-dimensional particles, somewhat similar to that of Squires and Squires. Under conditions of orientation where the particle exposes its maximum projected area normal to the direction of flow, this shape factor could be the ratio of the total exposed surface $\frac{2\pi d^2}{4} + Pt$ to the maximum projected area $\frac{\pi d^2}{4}$. Thus $R = \dfrac{\frac{2\pi d^2}{4} + Pt}{\frac{\pi d^2}{4}}$.

TERMINAL VELOCITY

Such a relationship is obviously artificial, but if it approximated the actual volume of a condensed particle it would be a useful method of correcting measured sizes of particles to their actual terminal velocities. The crushing technique developed by Boddy[6] seemed to offer an opportunity of establishing the accuracy with which the volume of particles might be assessed by this method. Some particles which had been measured and shadowed were crushed by Dr. Boddy and small plastics spheres (about 15 microns in diameter) were crushed alongside the particles and at the same time. The change in shape of the spheres to a thin circular disc allowed the final thickness of the crushed coal particles to be calculated. From this, and the measured final area of the condensed particle, its volume could be established. Fig. 5 shows the relationship between the calculated values for particle volumes using the mean thickness from the shadowed particles, and the actual volumes of the crushed particles. There is

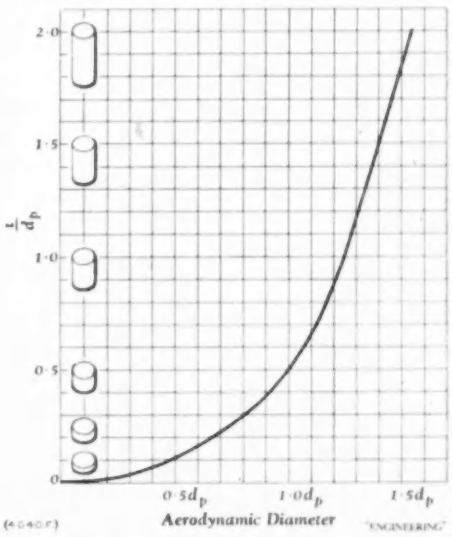

Fig. 6 Effect of particle thickness on terminal velocity.

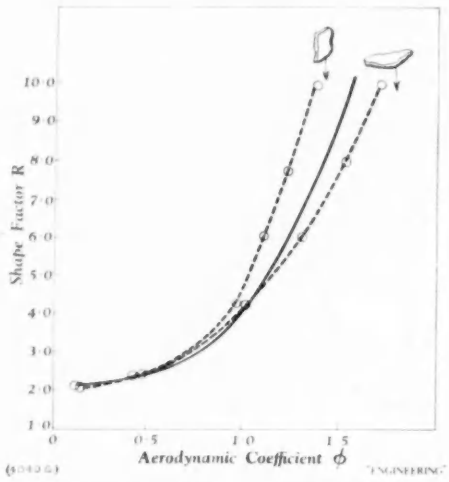

Fig. 7 Relationship between shape factor R and aerodynamic coefficient ϕ.

reasonable correspondence between the actual and calculated volumes, and the assumption that the volume and surface of a particle may be represented by the maximum projected area and mean thickness seems justified. Fig. 6 shows the effects of thickness on the terminal velocities of discs (based on Squires and Squires). It will be observed that the terminal velocities of a disc may vary between 0·1 and about 1·5 times the measured diameter of the particle. Thus thin laminae may well have terminal velocities down to 0·2 of their measured diameter, and so would be retained in the lung although their apparent size might seem to preclude their prior passage through the upper respiratory tract.

Fig. 7 indicates the effect of the particle shape factor derived from the mean thickness upon the terminal velocities of particles.

$$R = \frac{\text{exposed surface area}}{\text{maximum projected area}} = \frac{\frac{2\pi d^2}{4} + Pt}{\frac{\pi d^2}{4}}$$

ϕ is the factor by which the measured maximum projected diameter is multiplied in order to derive the probable terminal velocity. The dotted lines show the effects of orientation upon terminal velocity and are based upon Squires and Squires' calculations for discs of varying thickness. This suggests that somewhat similar conditions hold for the irregular particles, and that here again the presence of what appear to be large particles in human lungs may well be laminae possessing a very low ratio of exposed surface to maximum projected area. From the shadows cast by aggregating particle assemblies it seems likely that these also may have much lower terminal velocities than their apparent size would suggest. In this case the drag due to rather low total surface/projected area ratios may be more important in controlling terminal velocity than the actual volume or mass.

These results suggest that the orientation of particles as deposited may be influenced by the design and operation of the sampling unit, and that under vertical sedimentation by gravity, particles will tend to deposit in positions of maximum stability and thus exhibit their maximum projected areas for sizing. When subjected to passage through a horizontal sedimentation unit particles tend to orientate themselves along flow lines which are the resultants of the vertical movement due to gravity and the horizontal movement of the air stream. When deposited upon the collecting plates, however, most of the particles tend to exhibit their maximum projected areas. The sideways repulsion of particles in the thermal precipitator results in random deposition of the particles on the cover glasses, and it is possible that if the latter were horizontal the particles might show preferred orientation similar to that observed with the sedimentation units. The use of shape factors based upon the three dimensions of the particles suggests that variations in particle thickness may have large effects upon the terminal velocities as derived from studies of only two dimensions of the particles.

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[2] Watson, H. H., and Cruise, A. J., ENGINEERING, vol. 177, page 594, 1954.
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INDICATING GAS SPEED

PICK-UP FOR CATHODE RAY OSCILLOSCOPE

By T. J. Williams, M.SC., PH.D.*

It has been the practice of most investigators interested in the study of gas wave action in pipe systems to make use of cathode ray oscillograph engine indicators. Such indicators are normally supplied with pressure pick-ups or transducers, suitable for obtaining records of pressure variation in the ducts leading to, or from, reciprocating engines or compressors.

Where a single non-shock fronted pulse is propagated into air at rest at an absolute pressure P_0, it has been shown by Earnshaw[1] that the particle velocity w associated with a point at an absolute pressure P on the propagated wave is given by

$$w = 5\,a_0\left[\left(\frac{P}{P_0}\right)^{\frac{1}{7}} - 1\right] \quad . \quad (1)$$

where a_0 is the acoustic velocity in the undisturbed air ahead of the wave. The velocity of propagation, c, of the wave point is equal to the algebraic sum of the particle velocity and the local acoustic velocity, and is given by

$$c = a_0\left[6\left(\frac{P}{P_0}\right)^{\frac{1}{7}} - 5\right] \quad . \quad (2)$$

In such a case it is a simple matter to determine the particle velocity distribution corresponding to a given indicated pressure pattern. However, where two or more pulses cross, no simple relationship exists between the particle velocity and the resultant pressure. Considering, for example, two pulses propagated towards one another and eventually crossing, the particle velocity during the wave superimposition is given by[2]

$$w = 5\,a_0\left[\left(\frac{P_R}{P_0}\right)^{\frac{1}{7}} - \left(\frac{P_L}{P_0}\right)^{\frac{1}{7}}\right] \quad . \quad (3)$$

where P_R and P_L are the absolute pressures corresponding to the rightward and leftward moving waves respectively at the point considered. The resultant pressure P is given by

$$\left(\frac{P}{P_0}\right)^{\frac{1}{7}} = \left(\frac{P_R}{P_0}\right)^{\frac{1}{7}} + \left(\frac{P_L}{P_0}\right)^{\frac{1}{7}} - 1 \quad . \quad (4)$$

Thus the particle velocity w, is no longer a direct function of the wave pressure, and a knowledge of the form of both pressure waves before superimposition is necessary in order to determine the resultant particle velocity distribution. A further complication is introduced since the propagation velocity of any point on one of the waves varies continually as it crosses the other. The determination of which values of P_R and P_L should apply at a given position and instant is therefore a matter of some difficulty. Calculation of the particle velocities associated with a given pressure wave is further complicated by frictional effects and the presence of any shock-fronted waves in the pipe.

In a pipe system, wave reflection occurs at both ends of the pipe and at any change in pipe section. Thus although the generated pulsations may be propagated in one direction only, wave reflection soon results in a system of pulses traversing the pipe in both directions. At the open end of a pipe, for example, pressure waves are reflected as rarefactions, and vice versa, the incident and reflected waves tending to produce small resultant gauge pressures and increased particle velocities near the open end. At a closed end of a pipe system on the other hand, the gas velocity is zero while the gauge pressure is increased during reflection.

The advantage of having available a pick-up unit which will enable the form of the gas velocity variations at any given point to be shown on the cathode ray screen, in addition to the pressure pattern, is therefore evident.

The velocity pick-up described in this article was developed during the course of an investigation into the behaviour of viscous flow meters under pulsating flow conditions,[3] and was designed for use with an electromagnetic transducer. In the corresponding pressure pick-up, the pressure variations deflect a flexible diaphragm which produces a variation in the length of a small air gap in a magnetic circuit. The resulting change in magnetic flux generates an electromagnetic force in a small coil, the voltage generated being approximately proportional to the rate of change of pressure. The oscillograph unit usually incorporates an integrating circuit which converts the final diagram on the screen to one showing pressure variation over the cycle.

The velocity pick-up is shown in Fig. 1 and consisted of two Pitot tubes, D, $\frac{1}{16}$ in. bore, inserted into the pipe E, one facing upstream and the other downstream. The Pitot tubes were connected to two cells formed on each side of a diaphragm, the net force on the diaphragm being proportional to $K\rho v^2$, K being a factor dependent mainly on geometrical configuration and Reynolds number,[4] ρ and v referring to gas density and velocity respectively. Provided that changes in density are relatively small, the diaphragm deflection may be assumed to be approximately proportional to the square of the gas velocity provided the factor K can be assumed not to change to any significant extent over the range of gas velocity measured.

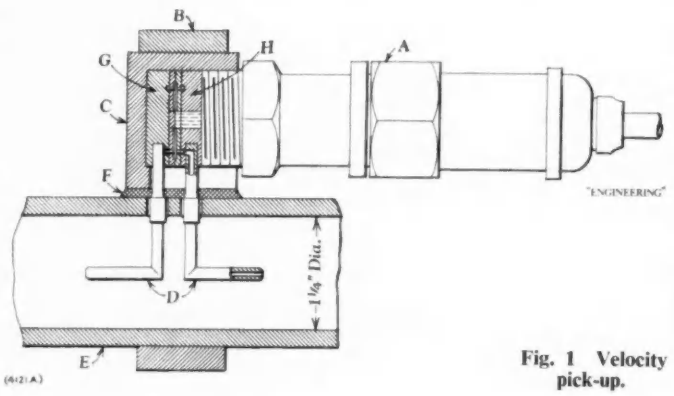

Fig. 1 Velocity pick-up.

* Department of Mechanical Engineering, University of London, King's College (formerly at Department of Engineering, University College of Swansea).

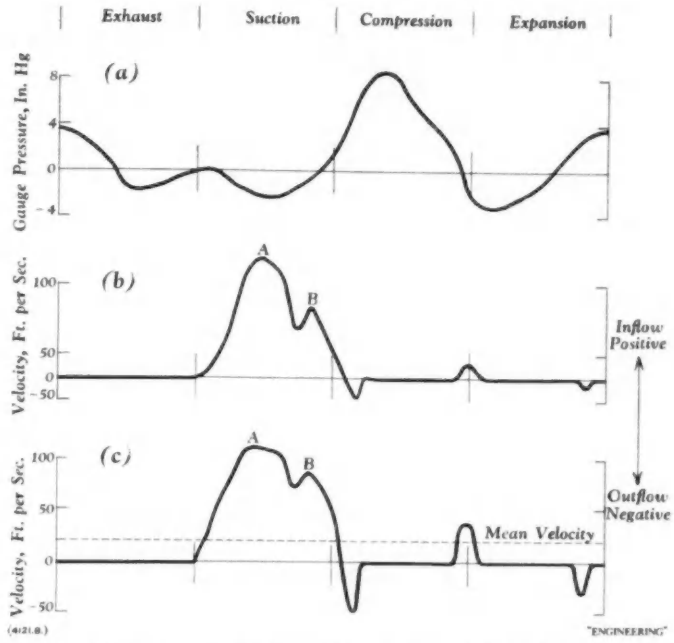

Fig. 2 Pressure and velocity diagrams near inlet valve of engine induction system.

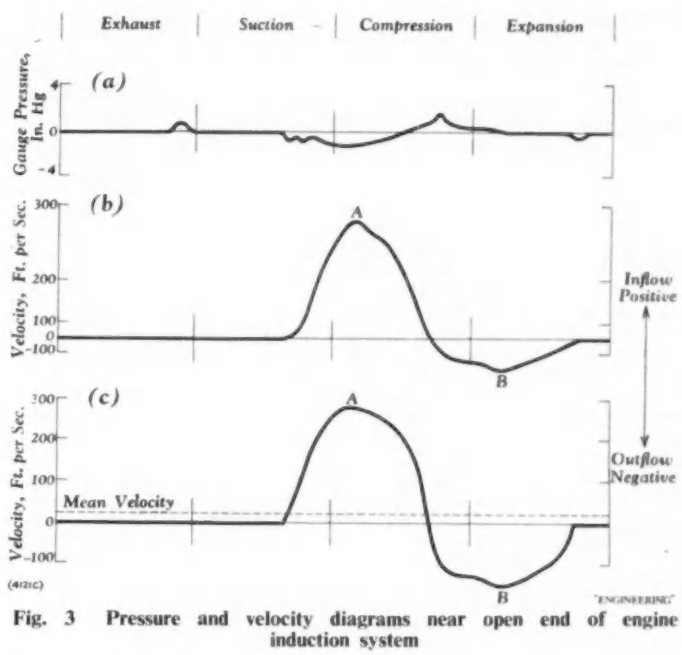

Fig. 3 Pressure and velocity diagrams near open end of engine induction system

It would, of course, have been possible to have used a Pitot-static tube in conjunction with the pick-up unit, or alternatively to have had one side of the diaphragm fed with the pressure from a Pitot tube, and the other connected to a static pressure tapping upstream in the pipe wall. Although there would be less variation in the value of K with either of these Pitot-static arrangements, it was nevertheless felt that the use of two Pitot tubes had very definite advantages. In the first place the available head across the diaphragm at a given gas velocity would be about 50 per cent. greater in the latter case, and this was important in view of the relative smallness of the velocity head. Secondly, the instrument as shown was capable of indicating flows in either direction, and flow reversals are often encountered. The chosen arrangement was also relatively easy to construct and install at a given indicating position. There was probably little to be gained in accuracy from the use of a Pitot-static arrangement since, not only was the influence of density changes on the resulting diagrams neglected, but the pulsating nature of the flow would also probably result in a variation of the form of the velocity profile across the pipe, and hence in the ratio of mean gas particle velocity at any instant to the corresponding gas velocity at the Pitot tube.

In order to obtain a record of the velocity variations at a point in a pipe, two small holes about $\frac{1}{4}$ in. in diameter were drilled at an axial distance of $\frac{3}{8}$ in. in the pipe wall. (See Fig. 1.) Pitot tubes of the appropriate size were then screwed into distributing discs G and H and inserted through holes in the rubber sealing sheet, F, and the pipe wall. The length of the Pitot tubes should preferably be such as to locate the tube openings at or near the centre of the pipe section and thus ensure the maximum velocity head. Clamping discs and the diaphragm were then placed between the distributing discs, and the holding block C was then slipped over the discs. The electromagnetic pick-up unit A, was then screwed into the holding block and the latter secured to the pipe by means of the clamp B. Having done this, it was then possible to tighten the pick-up unit so as to clamp the diaphragm securely.

An analysis, by the author,[5] of the behaviour of manometers under pulsating conditions has shown the dangers of having large capacities, restrictions, or long connecting leads in a pressure recording device. In the pick-up unit described it will be noted that the gas passages were identical on each side of the diaphragm, and that there was nowhere any sudden change in passage area. While the diameter of the gas cells tended to be somewhat larger than that normally employed in pressure pick-ups—due to the small velocity head—it was not anticipated that there would be any appreciable pressure lag in the gas cells with the bore of Pitot tubing used. When indicating the velocity in a 2 in. bore pipe, the length of Pitot tube would be about $2\frac{1}{2}$ in., but it was not felt that this would normally result in any errors due to phase lag, wave attenuation, or resonance in the tube. The recent work by Withers[6] on the effect of indicator passages on the accuracy of pressure diagrams would tend to support this assumption.

The force available to deflect the diaphragm of the velocity pick-up unit was, of course, very much smaller than that available in the corresponding pressure pick-up. Where a pressure wave of 5 in. of mercury amplitude was propagated into stationary atmospheric air, then from equation (1), the maximum particle velocity would be about 120 ft. per sec., and the corresponding velocity head available at the velocity pick up unit about 4·5 in. of water. With a pressure amplitude of 1 in. of mercury, the corresponding velocity head is only about 0·2 in. of water. Such small heads are normally too small to give a diagram of reasonable height on the screen of most engine indicators, and it is therefore necessary to use a pre-amplifier in conjunction with the main amplifier used.

Although the unit described was for use with an electromagnetic pick-up, there is no reason why velocity pick-up units of similar design should not be used in conjunction with other types of transducers.

Calibration of the "velocity squared" diagrams obtained presents certain difficulties. The balanced disc type of calibrating unit, normally used for calibrating pressure diagrams obtained by means of electromagnetic pick-ups, cannot be used with the small velocity heads normally available. The following procedure was therefore adopted. The "velocity squared" diagrams obtained on the screen of the indicating equipment were converted into diagrams of velocity against crank angle. To do this it was necessary to know the position of the velocity axis, and in most cases this could be determined by inspection. In order to prevent unjustifiable magnification of the ordinate scale, the maximum amplitude of the velocity diagram was made equal to that of the "velocity squared" diagram. Thus if $y_{max.}$ was the maximum amplitude of the latter curve relative to the zero velocity line, then other ordinates, y, must be multiplied by $\sqrt{\frac{y_{max.}}{y}}$ in order to obtain the corresponding amplitudes for the velocity diagram. The mean height of the velocity diagram was then determined by means of a planimeter. This height corresponded, of course, to the mean velocity of flow.

In many cases where the pick up was used in an engine induction system it would be possible to estimate the mean rate of air flow to the engine with reasonable accuracy, and hence to determine the velocity scale for the diagrams. A direct displacement apparatus was available at Swansea for metering accurately the air flow. The open end of the induction pipe was inserted into a large volume chamber, the metering apparatus measuring the air flow into this chamber. It was therefore possible to measure the engine air flow without interfering in any way with the form of the flow pulsations existing in the induction system when drawing air directly from the atmosphere.

It will be noted that where the ratio of maximum to mean velocity over the cycle is large there can be a considerable error in the scale as determined by the above method. Also in certain cases it may be difficult, if not impossible, to determine the position of the zero velocity line on the velocity squared diagram. Again small errors in the smaller ordinates of this diagram are magnified in the corresponding velocity diagram. However, in spite of these sources of error, the qualitative value alone of the velocity diagrams in interpreting the corresponding pressure diagrams justifies the use of the indicating pick up described.

EXPERIMENTAL RESULTS

Diagrams of pressure and velocity squared obtained near the inlet valve in an induction pipe leading to a single-cylinder four-stroke compression-ignition engine are shown in Fig. 2 (*a*) and (*b*). The induction pipe was 22 ft. long and $1\frac{3}{8}$ in. bore, and the engine speed 600 r.p.m. The corresponding velocity diagram derived from Fig. 2 (*b*) is shown in Fig. 2 (*c*). While the air particle flow was confined mainly to the period during which the inlet valve was open, pressure pulsations persisted throughout the cycle.

The main suction pulse is shown at A in Fig. 2 (*b*) and (*c*), and it can be seen that the particle velocity was boosted during the latter part of the suction pulse to give a second peak at B. This was due to the return of the leading portions of the suction pulse after reflction at the open end of the pipe. The reflected wave, being a positive pulse, increased the particle velocity of the

inflowing air, and resulted in the pressure being greater than atmospheric in the region of the inlet port when the valve closed. This would have the effect of increasing the volumetric efficiency of the engine, and it was found in this particular instance that the volumetric efficiency was about 10 per cent. greater than when no inlet pipe was used. With the particular length of induction system used, the ratio of induction pipe natural frequency to the inlet valve frequency at the engine speed of 600 r.p.m. was about 2·5, and this value is within a range normally expected to produce favourable pulse ramming effects in a single-cylinder four-stroke engine.[7]

Corresponding diagrams obtained near the open end of the induction pipe, this time at an engine speed of 800 r.p.m., are shown in Fig. 3. Little information was available from the pressure diagram Fig. 3 (*a*), since the incident pulses were almost immediately swallowed by the returning reflections from the open end. In the velocity diagrams, on the other hand, the suction pulse, strengthened by its reflection at the open end, is clearly shown at A. On comparing the amplitude of this pulse with the corresponding velocity amplitude of the suction pulse near the inlet valve, it was found that the effect of the open end reflection was roughly to double the particle velocity. This is in agreement with the theory of wave reflection.[2]

At 800 r.p.m., the reflected pressure wave from the open end would arrive back at the inlet port after the valve had closed, reflection would take place at the valve, and a " blow-back " pulse would be propagated towards the open end. This is shown at B in Fig. 3 (*b*) and (*c*), and was responsible for the blow back which was evident to anyone standing near the open end of the induction pipe.

Figs. 2 and 3 were chosen as examples to illustrate the use of the velocity pick-up. The accuracy of the diagrams would of course be dependent upon the engine indicator equipment used, but it is not the aim of the present article to comment on the various types of indicator available.

Conclusion.—The use of an electromagnetic pick-up for indicating gas velocity variations is of great advantage in interpreting the wave action occurring in a duct in which the flow is pulsating. The pick-up described is capable of indicating velocity variations such as those found in the induction system of a reciprocating engine.

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REFRIGERATION IN SHIPS

The Ministry of Transport and Civil Aviation has issued a notice to all shipowners and shipbuilders, drawing attention to the dangers of using methyl chloride in ships' refrigerating machinery. Refrigerating machinery using methyl chloride will not in future be accepted in passenger ships coming under the Ministry's survey. The Ministry also advise against its use in cargo ships.

Book Reviews

THE SHORTEST WAY HOME

Relaxation Methods in Theoretical Physics, Vol. II. A continuation of the treatise " Relaxation Methods in Engineering Science." By R. V. SOUTHWELL. *Clarendon Press: Oxford University Press, Amen House, Warwick-square, London, E.C.4.* (55*s.*)

Two books by Sir Richard Southwell on the applications of his relaxation methods have already been published in the Oxford Engineering Science Series. The first, entitled *Relaxation Methods in Engineering Science*, appeared in 1940, to be followed six years later by the first volume of a treatise on relaxation in theoretical physics, which is now completed by the publication of Volume II. The lapse of ten years between these two parts of a single work represents a considerable turnover of graduates and research workers, to some of whom the principles of relaxation may be so unfamiliar or its possibilities so little appreciated as to warrant a few words of explanation.

Southwell originally invented his " method of systematic relaxation of constraints " in order to determine the stresses in redundant structural frameworks. He saw that any set of assumed displacements could be maintained by applying constraints, for example by means of jacks; and that the true displacements due to a specified system of externally applied forces could be attained by systematically easing-off the jacks. Relaxation does the same sort of thing by computation. It applies to the errors of a trial solution a repetition of mathematical operations whereby the residuals (corresponding to the loads on the jacks other than that just eased-off) are progressively reduced by liquidation of the largest residual remaining after each operation, until eventually all the residual quantities converge within a specified margin of uncertainty. The procedure is analogous to the techniques of hand lapping a flat surface or levelling a sports ground, and represents a revolutionary difference of outlook from that of orthodox mathematics in that attention is all the time concentrated on the tentative, systematic removal of unwanted errors instead of striving directly after some wanted solution.

The fact that relaxation yields approximate results is no detriment either to its validity in principle or its value in practice since the procedure can always be continued until the residual errors are less than either the uncertainties in the data, or the degree of precision to which a structure can be built. It therefore offers an eminently satisfactory means of attack on the many types of engineering problem for which orthodox mathematical solutions are intractable or prohibitively laborious. In common with other engineering tools and scientific instruments, relaxation can be used with increasing skill and over an increasing variety of applications. Practice develops the art of using these methods efficiently so as to reach the desired results with a minimum of computational labour. The importance of this aspect was quickly realised by Southwell and his small team of enthusiasts when they started, some twenty years ago, to explore the possibilities of relaxation and to experiment with different techniques.

Since that time, advances in the art of relaxation and in the range of problems for which it has been employed, often with conspicuous success, have steadily progressed. In both these directions original contributions have been made by mathematical engineers and physicists in the ordinary course of their work, and Southwell has made effective use of many such examples to promote the knowledge and practice of his methods. Some of the most difficult problems that have so far yielded to relaxation attack arose during the war and, on security grounds, have only relatively recently been released for publication; but since they exemplify significant extensions in both the art and scope of relaxation, the treatise would have been incomplete and less valuable without reference to them. It is mainly for this reason, though partly also due to meticulous verification of relaxation studies from outside sources, that Volume II is published so long as ten years after its precursor.

It is literally a continuation of the first book on theoretical physics. Pages, chapters and section headings are numbered consecutively with those of Volume I, while the indexes and bibliography now appended cover the two-volume work. The opening chapters of the new book describe relaxation techniques for solving problems involving biharmonic equations such as arise in hydrodynamics and elasticity. The examples illustrating the mathematical procedures include analyses of the flexural distortion of flat plates, the stress system induced by tension in a standard " briquette " cement test-piece, and the distribution of stresses in a gravity dam and in the plate frame of a steam locomotive. Of particular interest in some of these stress problems is the pictorial comparison between the results obtained by relaxation and those derived from photo-elastic experiments.

Subsequent sections deal with modifications of the standard relaxational procedure to facilitate simultaneous computation of two functions of a set of independent variables. These so-called " two-diagram " techniques are suitable not only for stress determinations in plates subject to complex loading systems, but also to the analysis of stress systems in solids of revolution. Many problems occur in this field to which there is no practicable alternative to relaxation methods, and the applications considered include war-time studies of guns and artillery shells as well as the more general treatment of solids of revolution subject to radial and axial accelerations or to thermal stresses. A new relaxation concept —the progressive reduction towards a minimum of the ratio between two functions—is introduced to deal with eigenvalue problems, exemplified by normal free vibrations in stretched membranes or in electrodynamic systems, and by the more difficult cases of stable overstrain in flat plates.

Developments in stressed-skin aircraft construction have dictated a revised outlook on the permissible critical loadings of plates and panels exposed to conditions that may lead to large flexural or buckling distortions. The relevant non-linear equations present insuperable difficulties to orthodox analysis but a relaxational treatment is developed which, it is claimed, leads to a satisfactory result though it unfortunately entails so much labour that no typical example has been worked out. Some non-linear problems in hydrodynamics and plasticity, however, are discussed in relation to the special relaxation techniques invented to deal with them, and this theme is elaborated, in the concluding chapter, along general and speculative lines indicating how three-dimensional relaxation may be developed to deal with heat conduction and other transient problems.

The use of the words " theoretical physics " in the title of this book may seem anomalous since the subject headings and practical examples are preponderantly within the province of the engineer, more particularly the structural stress designer, rather than of the conventional physicist. The reasons, no doubt, are that the higher altitudes of engineering science can properly be regarded as a region of theoretical physics, and that Southwell's own uses of relaxation have primarily been in the subjects, particularly theory of elasticity, in which he has authoritative knowledge and is most deeply interested. Since Volume II is the latest and most advanced exposition of relaxation techniques that has yet appeared, it demands of the student a fairly high standard of mathematics and possibly a wider knowledge of theoretical elasticity than many engineers possess. For an increasing number of experimental workers, however, both in physics and engineering, and

especially for all who have already studied or practised relaxation, it is an indispensable complement to the two previous books. Its publication marks the consummation of what is, in every sense of the term, a *magnum opus*.

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BREAKOFFSKI AND OTHERS

The International Dictionary of Physics and Electronics. Edited by WALTER C. MICHELS and others. *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (120*s.*)

This dictionary, the co-operative effort of a distinguished team of ten scientists from the United States and four from this country, headed by Professor Michels of Bryn Mawr College, is the most comprehensive work of its kind to appear since the *Dictionary of Applied Physics* was published (also by Macmillan) 35 years ago. As that work consisted of five volumes, each having about the same number of pages as the one-volume dictionary now being considered, and as both physics and electronics have expanded enormously during the intervening years, it is obvious that the individual entries in the present work must necessarily be less encyclopaedic in their coverage. In fact, these entries range from single-line definitions to lengthy articles, such as that devoted to "Motor, Electric," which runs to three pages. In many respects, this concision in the presentation of essential information is an advantage, since any supplementary details required can always be sought elsewhere.

The 16 major divisions covered comprise units and dimensions (also the subject of a clear and useful introductory section), general principles, mechanics, the gaseous state, the liquid state, the solid state, heat and thermodynamics, acoustics, optics, electricity and magnetism, electronics, meteorology, atomic and nuclear physics, mathematical physics, quantum mechanics, and relativity. Wherever possible, definitions of terms conform with those recommemded by the various national and international standardising committees. Alongside these definitions are to be found amplifications in words, together with equations of the relative laws and empirical relationships, and descriptions of standard measuring instruments and apparatus. Frequently, there are circuit diagrams in addition. The large number of cross references included is another welcome feature and one that adds materially to the usefulness of the volume.

A few of the diagrams, however, such as that illustrating the formation of a pinhole image, hardly seem worth including in a work of so mature a general standard. Multiple entries abound: those beginning with the word "antenna," for instance, occupy seven pages. Room has also been found for a generous selection of the mathematical terms encountered in present-day physics as well as for a limited amount of information that might properly be classed as chemical. Thus, all the chemical elements are listed, though the only quantitative data given concerning them are their atomic numbers, and, in this connection, the English reader must remember to look for caesium under cesium. It is somewhat disconcerting to realise how overworked some of the letters of the alphabet are as symbols. For example, under the letter K (small or capital and with or without subscripts) 26 alternative meanings are listed, beginning with the "proportionality constant in force-mass equation" and ending with "reproduction factor, nuclear process."

There is no entry under end correction or under Poisson distribution (although there is a reference to it on page 218), and the diagram referred to under "Gas Thermometer," on page 382, is missing. The information under "Thermal Conductivity" relates exclusively to metals. There is no mention of the triple point of water as a fundamental fixed point in the definition of temperature, of the eikonal in optics, of the ammonia molecule or of the caesium atom under frequency standard. On the other hand, quite recent developments, such as the bubble chamber and the detection of the antiproton, are included, and, as representative of the lighter side of physics, there are references to "Breakoffski" and the "Electronic Bug."

In the first edition of a work of this magnitude some errors and misprints are inevitable. For example, on pages 94 and 1001 the biprism, generally credited to Fresnel, is attributed to Young. The spiral line referred to under "Chronograph," on page 143, is, in fact, a helix. On page 214, optional should read optimal; on page 363, cost should read cool; and, on page 747, λ-rays should read γ-rays. Variants in the spelling of proper names are fairly frequent, such as Couchy for Cauchy on page 1, Awberg for Awbery on page 72, Pirini on pages 120 and 384 (correctly given as Pirani on page 385), van Weizsacker for von Weizsäcker on page 124, Mosotti for Mossotti on page 149, Biot-Savant on page 207 (correctly given as Biot-Savart on page 94), Fresnel-Aragon for Fresnel-Arago on page 370, Manguin for Mauguin on pages 421 and 880, Bernouli on page 480 and Bernouilli on page 857 for Bernoulli, Taepler for Toepler on page 718, and Thollow on page 908 for Thollon (correctly spelt on page 709).

A new edition, such as the merits of the dictionary are likely soon to require, will enable these minor defects to be rectified. To have compressed such a wealth of authoritative and up-to-date information within the covers of a single, albeit large, volume, is a real achievement, and one for which all physicists and engineers will be grateful. The rate of progress in physics is now so rapid, however, that material for a supplement is already starting to accumulate, such as the confirmation of the existence of neutrinos and antineutrinos.

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EARLY SHORT CIRCUITS

The History of Electric Wiring. By JOHN MELLANBY. *Macdonald and Company (Publishers), Limited, 16 Maddox-street, London, W.1.* (32*s.* 6*d.*)

In common parlance the term wiring applies to that part of an electrical installation, which lies between the supply undertaking's main fuses and switches and the consumer's power, heating and lighting equipment. It comprises not only the connecting cables, but switches of various kinds as well as plugs and sockets, fuse and control gear and numerous accessories, in the design and installation of which a good deal of ingenuity, sometimes misplaced, has been expended. Very much has been written on the subject, mainly from the factual aspect. Mr. Mellanby not only follows this example, but brings in many of the personalities who have been responsible for the developments. He also sometimes touches, with unkind irony, on some of the events that have taken place in the industry. His book therefore not only contains a great deal of useful technical information, but may be recommended for study, especially by the older generation, when they can spare time from watching television for reading.

In one respect Mr. Mellanby's title is a little misleading. His first six chapters trace the invention and development of many of the devices now in common use, three being devoted to the period between 1870 and 1900 and the others to that between 1900 and 1954. In doing this he brings in a good deal of matter, which is extraneous to his main subject—legislation, the role of insurance companies in dealing with fire risks, earthing, lamp manufacture, the relative price of electricity and gas in the early days, the battle of the systems and above all, succinct biographies of personalities. In doing so he has collected a great deal of interesting information and has made some sound comments. For instance, he has, surprisingly, a good word to say for the Electric Lighting Act of 1882 on the grounds that its much criticised restrictions prevented mistakes being made from which we should subsequently have suffered. In dealing with systems of supply, too, it is pointed out that the employment of alternating current in the nineties was hampered by the misconception that lead or other metal-covered cable could not be used for its distribution. The scope of the book is therefore wider than might at first sight appear.

An interesting digression from the main subject is an account of Kelvin's work on electric light and power. This includes descriptions of the pioneer installation for which he was responsible at Glasgow University, and of which remnants were still in use until 1943, of his house at Largs and of other projects, including that at Peterhouse, Cambridge, for which he was responsible financially rather than technically.

The principal part of the book then follows. In it nine chapters are devoted to the development of cables, conduit systems, branch switches, lampholders and ceiling roses, plugs and sockets, fuse and control gear, busbar trunking and duct systems and prefabrication. There is also a short concluding chapter on recent developments. This is all carried out in considerable detail and is well illustrated, in the case of the earlier accessories by woodcuts. The descriptions make clear the ingenuity displayed in invention. For instance, no fewer than 58 types of turn switches were patented between 1884 and 1892, although this type disappeared as the tumbler (or tummler) switch, which had been invented in 1883, increased in popularity. The number of other accessories was also very large. Indeed, it is only recently that a combination of standardisation, increased technical knowledge and, probably, economics, has led to their reduction.

A close study of Mr. Mellanby's book has not disclosed any inaccurate information and, as too seldom happens, a long bibliography adds to its undoubted technical value.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Non-Ferrous Castings. CHARLES CARR, LTD., Grovelane, Smethwick, 40. Castings up to 2 tons in phosphor bronze, gunmetal, manganese bronze, and aluminium bronze. A range of some 16 alloys is listed as being in normal production, and others are cast as required. Products include all types of castings, sand and shell moulded, to customers' orders, brazing solders, railway axlebox bearings, chill-cast bars and machined bushes. Illustrated brochure.

Non-Sparking Tools. CHARLES CARR, LTD., Grovelane, Smethwick, 40. Cast aluminium-bronze tools for use in areas where sparking would be dangerous. Standard patterns include spades, shovels and picks (both for hand use and for pneumatic tools), scrapers, chisels, hammers and spanners. Illustrated brochure with prices.

Filters. AIRPEL LTD., Lower-road, Chalfont St. Peter, Bucks. Industrial fluid filters for high and low pressure systems; single and dual models. Working pressures up to 750 lb. per sq. in. and capacities to 8,000 gall. per hour (water). Also delivery nozzles and hand pumps with built-in filters. Catalogue.

Short-Circuit Testing. THE ASSOCIATION OF SHORT-CIRCUIT TESTING AUTHORITIES (INC.), 36 Kingsway, London, W.C.2. Asta publication number one gives an account of the Association and the facilities available to manufacturers. Illustrated brochure.

Plate Conveyor. RICHARD SUTCLIFFE LTD., Horbury, Wakefield. "Crocodile" steel plate conveyor, primarily for mines. Made in three widths and three depths with capacities up to 750 tons per hour. Illustrated brochure.

Inert Gland Packing. CRANE PACKING LTD., Slough, Bucks. "Superlon" gland packing material based on Fluon. Temperature range — 40 deg. F. to + 500 deg. F. Unaffected by most chemicals and non-toxic. Leaflet.

TOOLS AND JIGS MADE FROM MASTER MOULDS

FRENCH AIRCRAFT TECHNIQUES

A survey "Modern Methods of Aircraft Production" formed the subject of the tenth Louis Blériot lecture, given recently before the Royal Aeronautical Society in London by M. Paul Badré, production director of the French aircraft company Ouest Aviation. Tracing the production stages from the drawing office to final inspection and flight testing, M. Badré reviewed techniques which have recently come into prominence, such as copy milling, skin milling and chemical milling, transfer machines, finishing-machining on the assembly jig, hydraulic forming presses and stretch-forming processes. We give below extracts from the latter part of the lecture in which M. Badré discusses French applications of the use of full-scale models for the production of press-forming tools and assembly jigs.

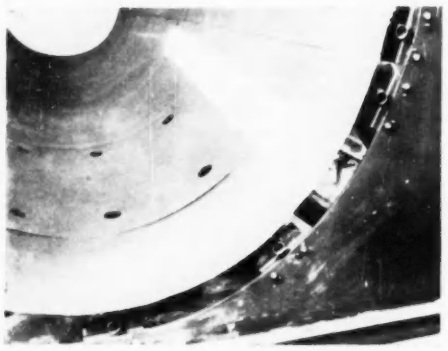

Fig. 1 A plaster model of a fuselage longeron is built on to a hollow plastics fuselage mould.

A fairly well-known method for making stretch forming tools is to make a full-scale plaster model of the component, starting from drawings of sections. For a fuselage, for example, the frames are traced directly on metal and, after being cut, serve, together with very light struts, to represent a skeleton. The spaces in this skeleton are filled with some packing material, such as wire gauze, stuffing, even straw incorporated with plaster and sometimes bound with resin. The surface is made perfectly smooth so that a fuselage exactly similar to the final version can be constructed. It is possible to trace directly on this fuselage, with a scriber, all the intersections and all the fixing joints of given components, including wings, tail units and supports for various equipment.

When the fuselage form has been constructed, hollow plastics moulds are cast over it. When removed, the press tool is made by pouring on a thermosetting plastics substance into the mould. The thickness of the metal sheet is taken into consideration during this casting process by a suitable decrease in the thickness of the model. By applying a thin film of "separator" the resin is kept from sticking to the plaster and the line marked on the model by the point of the scriber can be made to stand out on the mould. This method also provides a basis for the assembly jig on which will be fitted the various supports, frames and different components making up the aircraft structure.

If a spar has to be fitted into some part of the structure, there is no reason why a plaster model of the spar (Fig. 1) should not be built on the hollow form already obtained, and the press tool for making the spar cast from this model (Figs. 2 and 3). The fuselage longeron of the Vautour aircraft provides a good illustration of this process (Fig. 4).

The Vautour longeron was made on a large press brake in the St. Nazaire works of Ouest Aviation. The use of more conventional methods would have demanded tools which would probably have taken several months to produce and several weeks to perfect. This simple method of reproduction by casting from a model enabled the firm to produce the tools in a little under a fortnight and proved entirely satisfactory.

During recent years methods of assembly have undergone a marked development. The Fairey Aviation Company were the first to conceive the idea of "envelope jigging"—starting the work of construction from the outside instead of from the inside. The skin, already provided with its various stiffeners, becomes the basic component on which the various pieces of the skeleton are fixed. The result, when assembled, is a perfectly smooth unit, with no deformations or internal stresses.

A variant of this method, now in use in France, is to have plastics counter-moulds for the outside walls of the jigging, generally made of epoxy resins with various additives, on which will be fixed the attachment points of the other components of the structure. These epoxy resin counter-moulds are obtained directly from the models mentioned earlier. Since both the components and their assembly jig come from the master model, the tooling is adjusted right from the beginning and the parts fit well from the start. Fig. 5 shows the rear fuselage of the Mystère IV made by this method, which has also been used extensively in Vautour production. The chief justification of the method is that the first production aircraft was fitted and assembled as easily as the 10th, 15th or 20th.

After completion of the assembly comes the installation in the aircraft of all the necessary pipes, ducts, instruments and services. The present tendency, in evidence now for a number of years, is to produce separately the various

Fig. 2

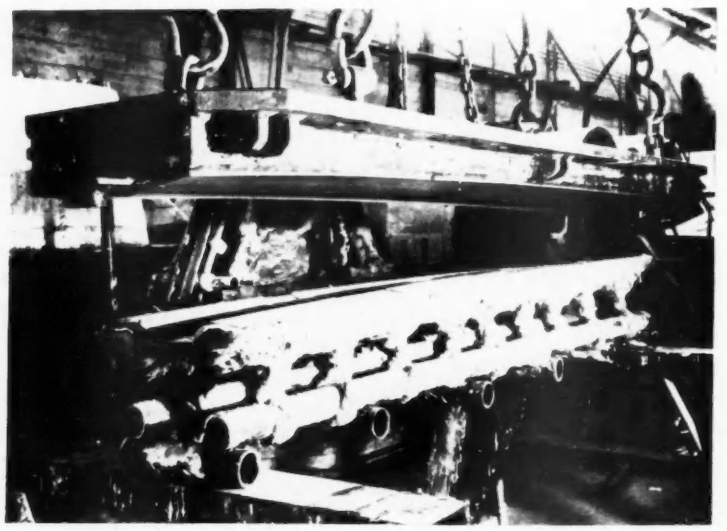

Fig. 3

Figs. 2 and 3 Plastics press tools for forming the longeron can be built up on the plaster model shown in Fig. 1.

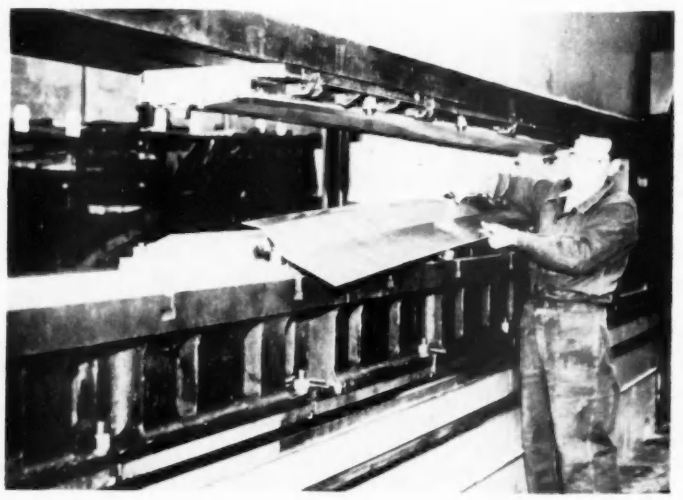

Fig. 4 A fuselage longeron of the Vautour aircraft formed in a large press utilising moulded tools.

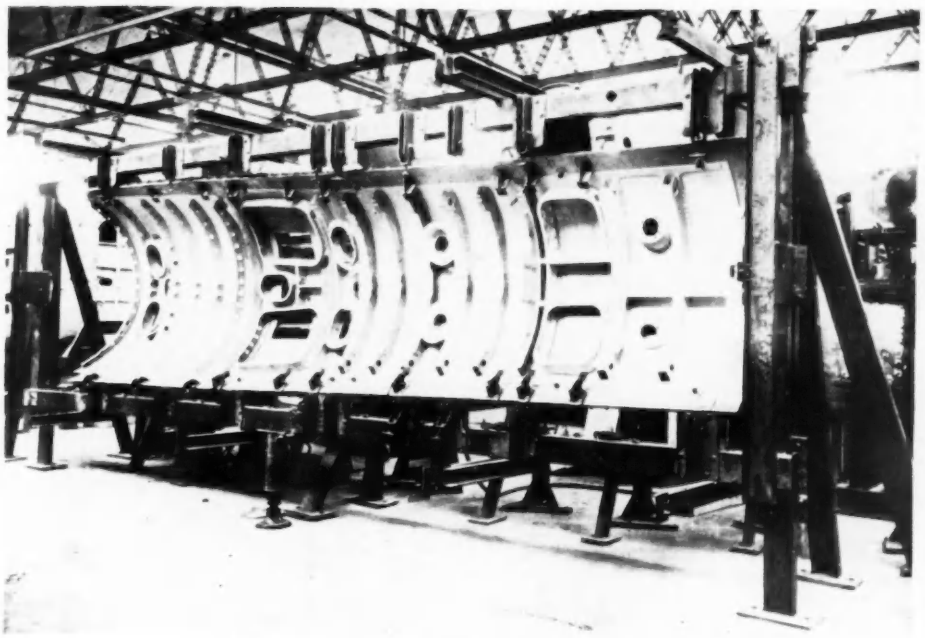

Fig. 5 A rear fuselage panel of the Mystère IV produced in an envelope jig.

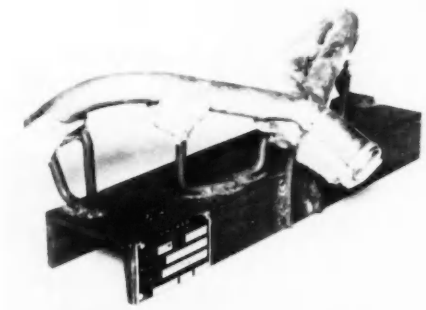

Fig. 6 Pipe-forming jigs in plastics built up on a full-scale metal mock-up of aircraft.

systems of pipes, wiring looms complete with junction boxes, plug sockets and all the necessary ancillaries, and to place these components on supports, the positions of which have been carefully pre-determined, with the minimum of fixing required and consequently the least expenditure of labour.

A method which is believed to be original (it is apparently now being applied by Lockheed for the manufacture of the Electra) has been used in France during the past few years. A full-scale metal model of the aircraft is made using the same components, usually from rejected parts, as the structure itself. The positions and the shapes of the pipes are then determined by a process similar to the moulding process on the plaster models used for the structure (Fig. 6). In this way systems of piping, together with standard assemblies representing all the pipes, however complicated, can be worked out at leisure and made in due course by a sub-contractor and subsequently fitted on the aircraft without difficulty. These methods have been employed in France on aircraft such as the Vautour and the Mystère IVA, resulting in a very appreciable saving in time.

SAFE USE OF ELECTRICITY ON BUILDING SITES

The increasing employment of electricity on building sites lent a topical interest to a lecture, which was delivered on February 20 by Mr. S. J. Emerson, H.M. Senior Electrical Inspector of Factories, to the London Building and Engineering Contractors Accident Prevention Group. There was, he said, a tendency in the building industry to take the dangers of electricity too lightly, with the result that it was the failure of the individual and not defective apparatus which was responsible for a great many accidents.

In many cases, in the past, safety on buildings in course of construction had been sacrificed to the search for the cheapest possible job and the electrical equipment had not always been installed with a full appreciation of the many considerations involved to ensure safe usage. Extra heavy tough rubber-sheathed cable should always be employed both for portable apparatus and for fixed temporary wiring, and only extension connectors of robust construction, which fully protected the flexible cable at the point of entry to the apparatus, and provided with efficient end grips, should be used. Wherever possible, solid-rubber type plugs and sockets should be employed.

Speaking generally, the fundamental requirements for safety were the use of well designed and constructed apparatus, properly installed and efficiently maintained at all times. To facilitate this, records should be kept of all tests and inspections, so that any gradual deterioration might be readily detected. It was interesting to note that about two-thirds of the electrical fatalaties occurred at voltages below 250 and that of this number between 60 and 80 per cent. were associated with portable or transportable apparatus. It followed that if the recommendation made by the Factory Department to reduce the voltage for portable tools and hand inspection lamps were adopted, the fatal accidents due to electricity would be halved.

A suitable voltage for portable tools was 110 volts with the mid-point of the secondary winding of the step-down transformer earthed, so as to restrict the shock voltage to earth to 55 volts. An additional safeguard was to employ earth leakage protection, while precautions should also be taken against danger arising owing to the earth wire becoming detached. As the safety of portable apparatus depended so much on the continuity of the earth at the time of a fault, in cases where the use of low voltage was impracticable, a circulating current should be applied through the connection so that, in the event of the earth conductor breaking or a high resistance occurring in any part of the earth circuit, the main switch would trip and isolate the apparatus. A number of such systems which failed to safety had been developed. When medium-voltage alternating current was used for heavy transportable apparatus it was preferable that the supply should be through a one-to-one isolating transformer with an earth leakage relay in the connection to earth from the centre point or neutral of the secondary. The high-cycle system (200 cycles) provided a low shock voltage (76 volts) to earth and was simple and reliable for use with squirrel-cage rotors.

Safety measures by themselves could not, however, be regarded as sufficient to ensure the desired results. Good equipment, well maintained, was essential, particular attention being paid to the flexible cable and its connections and to the continuity of the earth conductor.

* * *

MORE ELECTRICITY IN EUROPE

The present position and future trends in the European electricity supply industry are set out in great detail in a report recently published by the Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris XVI[e]. In general terms, there was a global increase in electricity consumption of 9 per cent. per annum from 1953 to 1956, which was 2 per cent. higher than that noted in previous years. The average annual output from public-utility thermal plant during the same period increased by 10·2 per cent., as against 7 per cent. from water power. The total capacity of the power stations rose from 90,600 MW in 1954 to 97,600 MW in 1955, an increase of 7·7 per cent. It appears from figures, which have been collected, that while the production from water-power plant will continue to increase, by 1961 it will only account for 36 per cent. of the total production of the member countries, compared with 41 per cent. in 1956. The annual rate of increase in output will, it is estimated, tend to drop from 9·8 per cent. in 1953-54 to 5·7 per cent. in 1960-61. During the 1954-56 period consumption in the industrial and household sectors increased by 7·3 per cent. and 8·1 per cent., respectively. Germany showed a particularly sharp rise in household consumption, that is, almost 11 per cent. per annum as against 7·9 per cent. in France and 7·5 per cent. in the United Kingdom during the same period. It is considered that while the use of brown coal, fuel oil and natural gas will increase up till 1961, in which year fuel oil will account for 12·2 per cent. of the total thermal production, coal will remain the basic fuel. The thermal efficiency is improving year by year and by 1961 should reach an average of 27 per cent. on a " sent out " basis in stations fired with high grade fuel. Some of the more modern stations have already exceeded 35 per cent.

Perhaps the most interesting part of the report is a series of tables showing the net capacity installed in the individual member countries in the period from 1954-61. The figures for all but the first two of these years are, of course, estimated and a distinction is drawn between interconnected and non-interconnected countries. Similar figures for the same period are given for maximum peak capacity, production, consumption under various headings and output of thermal plant according to the type of fuel used. In 1954 the net capacity installed in the United Kingdom was 23,600 MW, of which all but 700 MW was thermal plant. The second place was occupied by Germany with 15,342 MW, of which 12,772 MW was thermal plant and the third by France with 13,644 MW, of which 7,476 MW was water-power plant. In 1961, although there will be no change in the relative positions, the United Kingdom still leading with 35,500 MW, Germany, it is estimated, will have reached 28,670 MW and France will only have advanced to 20,600 MW, of which 9,800 MW will be water-power plant.

Marketing

COMPETE OR BE DOOMED

A chill wind or a breath of fresh air, depending on one's outlook, is blowing through British industry. Sir Graham Hayman, the President of the Federation of British Industries, said recently that companies must be prepared to face much greater competition in all their markets. He referred particularly to the passing of the Restrictive Practices Act and to the opening moves aimed at establishing a free trade area in Europe. He could have mentioned G.A.T.T., United States and German pressure for the convertibility of currencies, the recent concessions to Australia on preference margins and other disturbing factors.

The next decade is likely to see a vast increase in world trade. Manufacturers' fears at losing all protection almost overnight are real enough, and understandable, but their opportunities can seldom have been greater.

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. . . or be Damned

British businesses rushed in to beat the time limit for the registration of their agreements to limit competition. On the last day of the period allowed, the new Registrar of Restrictive Practices received as many registrations as during the whole of the previous twelve weeks. Something over 1,200 agreements to restrict competition have now been notified and the work of compiling a register which will be open to public inspection by mid-April is proceeding. The Restrictive Practices Tribunal will then begin to consider each agreement in relation to the public interest.

The Act strikes at a deeply-rooted habit of British industry. If the Tribunal is successful in eradicating it (this could prove devilishly difficult to do, and very slow) industry may find itself strangely unable to adapt itself. For example, what would result if Mullard's are forced to end self-imposed restrictions on their immeasurably greater ability to become even more competitive? Almost certainly a bigger monopoly—though doubtless a cheaper product. This time, however, it is a case of compete or be damned.

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Who Studies the Market?

A plea for more and wider use of market research was made by Mr. Leslie Gamage, vice-chairman and joint-managing director of the General Electric Company, in a recent address to the Incorporated Sales Managers' Association. A large proportion of the sales manager's time should be spent in overseas markets if his company are primarily engaged in exporting. " Only in this way," said Sir Leslie, " can he study for himself the local climatic and economic conditions and savour the influences which ease the sale of his products."

Few would argue against the sales manager having first-hand knowledge and experience of the opportunities and obstacles his overseas force are likely to meet. But essentially a sales manager's task is to manage. To be studying import and export regulations or to spend long periods overseas doing market research will only be done at the expense of his management task. Frequent visits to overseas markets are essential, to keep in touch with staff and agents, as are visits to sales areas at home for the same purpose. A sales manager must know what his staff are doing. Someone else should provide him with market information.

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China Trade

Growing pressure is being exercised on the Government to secure the removal of the strategic embargo on trade with China. The Sino-British Trade Committee, representing the Federation of British Industries, the National Union of Manufacturers, the China Association, the Associations of British Chambers of Commerce and the London Chamber of Commerce, wrote to the President of the Board of Trade asking that the embargo should be removed or at least that trade should be put on the same footing as trade with the Soviet Union. This has been done in the hope that the Prime Minister will raise the matter with President Eisenhower during their forthcoming meeting in Bermuda.

Leading trade associations take the view that the embargo is preventing British companies from competing with other European countries, particularly Western Germany, and with the Soviet Union. That country is said to be supplying some 80 per cent. of China's imports and to be building up a strong position of advantage. Even goods obtained from the west are being shipped through Communist bloc countries, thus increasing their political influence. A good demand for steel, heavy machinery, tractors, lorries and machine tools is known to exist. It is high time British manufacturers were allowed to stake their claim to what may become the largest market for engineering goods.

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Recovery in Latin America

British exports to South America have increased substantially during the past year, particularly to Venezuela and Brazil. The increase in the profits of the Bank of London and South America show that invisible earnings have improved also. The chairman of the Bank, Sir Francis Glyn, considers that the Latin American market may prove of far greater importance—" in the not too distant future "—and made a strong plea for further finance for exports. The needs of the importer for long-term credit " might easily outstrip the resources that the banks could prudently make available for this type of business." He suggests that other institutions—presumably insurance companies—should be invited to assist British exporters by providing the necessary finance.

The increase in British exports to Venezuela, which now accounts for a quarter of the total to Latin America, shows what can be done in a highly competitive market if potential rewards provide an adequate incentive to the more efficient and enterprising firms. The same applies to Brazil, where British exports doubled last year. The change over from lateral to multilateral trading brought in competition, but it also created opportunities which were well taken by British firms. Yet the amount exported to Latin America is pitifully small: £136 million last year, compared to £119 million to the Netherlands alone. Together with finance, an aggressive sales policy is urgently required.

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Manufacturing Abroad

British firms are turning more and more to the setting up of manufacturing facilities overseas in order to secure or improve their trading position. In a growing number of cases this is made inevitable by the policies of high protection walls adopted by Governments to foster the growth of local industry, as in Australia, South Africa and Brazil. In other cases, particularly where competition is intense, it is necessary in order to become established.

Massey-Harris-Ferguson have formed a new company in Brazil, in order " to promote the manufacture, assembly and distribution of tractors and implements suited to this market." Foundry Services Limited, who make chemicals for use in the manufacture of castings, have obtained a concession from the Japanese Government to build a factory near Okayama. They now have subsidiary or associated companies in nine countries. Such developments are a heartening sign of the efforts British industry is making to re-establish the leading position it once held as the world's suppliers of engineering products.

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Centralised Marketing

The growth of groups in manufacturing industry which has gathered such momentum since the war is leading to fundamental changes in organisation, particularly in marketing techniques. The magnitude of this change, and its significance, was the subject of a recent announcement by the Birfield group, which includes 17 manufacturing units with a combined turnover of £17 million last year. Explaining the purpose and aims of the group's new centralised selling organisation their chairman, Mr. H. E. Hill, said that it constituted " a powerful concentration of pooled knowledge and resources . . . to which each company will contribute and from which each can draw." The principal advantages mentioned by Mr. Hill are the elimination of duplication in the representation of the group's companies, and an opportunity to co-ordinate the development and production programmes of the various units. Customers—mainly in transport engineering—will have fewer people to deal with, and a more effective collaboration with the design and manufacturing organisations of the motor vehicle firms as well as with other customers should follow.

Birfield consider that their centralised selling organisation will enable them " to lay greater emphasis on export " than was open to individual members of the group. There are undoubted advantages, particularly in co-ordination and market research, but it is not generally sound to give a representative too many different products to sell. This, and effective liaison with the production control departments of the manufacturing companies, may prove to be Birfield's greatest problem.

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Americans in Europe

American manufacturers of engineering products are taking very seriously the current European trade developments. A considerable strengthening of marketing organisation is likely to take place to offset some of the disadvantages that are expected to follow the integration of European trade. The most effective counter is the establishment of local manufacture and just this is being done jointly by the Bellows Company of Akron, Ohio and Richardson Scale Company of Clifton, N.J.

A new company, Richardson-Bellows S.A. has been formed at Geneva to manufacture and distribute Richardson's automatic weighing and proportioning equipment as well as Bellows " controlled air power " devices. The common market, and the shortage of dollars, may well bring an influx of United States capital unparalleled in Europe's history.

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Service in Africa

Motor vehicle manufacturers are making a vigorous drive to regain lost ground abroad. The Rootes Group recently announced the establishment of a sales, servicing and maintenance organisation in Nairobi. This marks a significant change in the merchandising of British cars and commercial vehicles in East Africa where these functions have hitherto been discharged by agents. A team of specialists will be sent from England to initiate the change and a considerable improvement is expected to result in service to the customer. Such developments are welcome indeed, and the kind of tonic owners of British vehicles abroad needed.

FINANCE FOR INDUSTRY

There is some danger that private industry may not be able to get all the capital it needs to sustain growth and technical progress. So far, since the war, it has done so largely out of its own pocket from corporate savings. Narrower profit margins and possibly even steeper taxation of retained profits could reduce this source to an inadequate level. The private investor, able and willing to take a risk has become something of a relic in most countries in Europe: incomes have been equalised and small savings—in the form of life insurance or pension contributions—have been channelled through the institutional investor who has no tradition of risk taking. To cap it all, the policies of Governments can syphon off too much of their countries' savings into public expenditure—be it national health or armaments or "cheap" housing (cheap to the tenant)—to leave enough for the needs of industry.

The distressing manner in this country in which rail transport, roads, coal mining, shipbuilding, to name only a few industries, have been starved of capital, and the consequences we now bear, is illustration enough of what awaits industry as a whole, however enterprising and far-sighted, if its profits fall below the safety line.

This danger is one of the principal conclusions of a report published by the European Productivity Agency of O.E.E.C. entitled *The Supply of Capital Funds for Industrial Development in Europe*. This was prepared by Lord Piercy in collaboration with the national consultants of ten countries, including the United States and Germany.

The fact that Lord Piercy is also chairman of the Industrial and Commercial Finance Corporation (I.C.F.C.) and therefore most closely in touch with the financial problems of the small to medium company in post-war Britain, lends special weight to the report's main conclusions, which are as follows.

(1) High post-war expenditure by Governments has reduced the scope for private saving, as has the greater equalisation of net personal incomes; "Both influences may be regarded as permanent factors."

(2) The savings of companies and firms have been of major importance to capital investment. If they should fall, there "might be a wide gap" which cannot be filled.

(3) Institutions and funds, now the main channel for small savings, are slow to take the plan of the pre-war large private investor. This militates against the chances of the small to medium firm and of some large ones.

(4) The part traditionally played by the banks is being affected by Government influence on advances policy: "it will be of great interest to see whether this strategic change in policy proves merely temporary."

(5) There is a tendency for private enterprise to finance itself by bond issues or loans: this cannot satisfy the needs of competitive industry. Is risk-capital drying up and the equity being eclipsed?

Much of this is disturbing. All or most of it is of absorbing interest with a direct (perhaps a little painful) bearing on men, management and machines.

INDUSTRY FOR INDIA

India is busy taking advice on how it may become a major industrial power. The reports of two missions, one British and the other Soviet, are currently being considered by the Indian Government. In both cases industrial interests are believed to be prepared to co-operate on the implementation of the plans with equipment, technicians, training facilities and—if the plans are to go ahead quickly—a great deal of capital.

It was also announced during last week that the Government of India have accepted a British plan for a factory to manufacture heavy electrical equipment. The project report for the electrical engineering factory was drawn up by Associated Electrical Industries as consultants to the Government of India and provides for the erection of a factory at Bhopal in Central India, of which the first stage will be ready by 1960. The full scheme is expected to be completed by 1968 and will cost in the region of £34 million.

The report of the United Kingdom Heavy Engineering Mission which visited India towards the end of last year under the leadership of Sir Eric Coates has not yet been published but some of the recommendations were recently made known in India. They are aimed at providing capacity to process iron and steel products (mainly plate, heavy sections, castings and forgings) and to make the heavy plant and equipment needed for iron and steel works, structural engineering, chemical and fertiliser works, agriculture and mining.

Several projects are recommended including the establishment of five large self-contained plants: a heavy structural fabricating works; a heavy plate plant where pressure vessels, storage tanks and blast furnaces could be made; a works for the machining of heavy castings and forgings; a machine tool factory for the production of big machines such as vertical borers; and a specialised factory for making mining machinery.

These plants would serve to supplement plant and machinery capacity already planned by the National Industrial Development Corporation to make heavy castings and forgings. Additional capacity if required could be obtained by duplicating one or more of these units. The Mission has, for example, indicated that by setting up one machine tool works, two plate works and two structural bays enough capacity could be created to provide the bulk of the machinery needed for six fertiliser plants of the size of Sindri. It would be possible to provide locally much of the machinery required to set up four further steel works envisaged in the third five year plan.

The cost of building the initial five plants is estimated at Rs. 50 million (£3¾ million) for each of the first four and Rs. 30 million for the mining machinery factory. These estimates exclude the cost of the site, the erection of housing for workers and working capital. The report contains recommendations concerning the technical training of the staff required to run the plants, pointing out that for heavy engineering the proportion of skilled workers is inevitably high. Should the Indian Government accept the recommendations and request British assistance there is little doubt that the training of Indian labour in this country would be involved.

The report by the Russian Mission proposes one large factory which it is claimed would achieve economies by centralising the production of the various heavy engineering plants. Apart from the technical differences, an important factor in the Indian Government's decision will undoubtedly be the type of financial assistance likely to be offered by the two countries. If the British proposals are accepted the result must be a very heavy volume of orders for the necessary plant and machinery.

Much has yet to come. Heavy electrical engineering and further expansion of textile machinery and machine-tool manufacturing capacity is inevitable. Meanwhile, and for many years ahead India should become one of the leading markets for British engineering products as was Russia during the inter-war period.

ANALYSING LOST MACHINE TIME

Production Stoppages Recorded

It is useful both to the employer and employee to know how much time is spent in actual production and how much in waiting for materials or for repairs following breakdown. A device for making this analysis is now being sold by Headland Engineering Developments, Limited, 164-168 Westminster Bridge-road, London, S.E.1, which is called the Meetap, and is of Dutch design. The recording portion is shown in the illustration. On the analyser panel is a 10 position switch which is numbered to correspond to the panels on the indicator, which show actual production time, signal time and any 10 typical causes of production stoppage. There are also unnumbered intermediate positions on the switch.

When the indicator on the switch is set at any intermediate position, as soon as the machine is producing, the production time will be logged on the production meter. If the machine stops, the warning signal operates and its duration is logged on the appropriate meter, while the

With the switch set at an intermediate position, the analyser records production time. Lost time is recorded by the operator setting the switch to the appropriate cause.

production log will stop. The warning signal will continue to operate (and be recorded) until the machine minder turns the switch indicator to the number denoting the cause of stoppage. The signal will then cease and the appropriate "cause of stoppage" meter will log the duration of idle time. As soon as production recommences, the meter immediately starts recording production again and the warning signal re-starts until the operator turns the switch indicator to one of the intermediate positions. However, any delay in carrying this out is not recorded on the signal meter. An analysis card is provided for each machine, and is filled in at the end of every working period, day or week. In this way the time spent on the machine is analysed and the causes of lost production can be pin-pointed. A special switch is fitted on to the machine, the type of which will vary according to whether production commences when the motor starts running or whether the machine drive runs idle without producing, as in the case of printing, textile or paper machines. A power-pack supplies the necessary signals to the analyser and one pack can operate up to six analysers.

FURNACE FLAME INDICATOR

REMOTE INSPECTION OF COMBUSTION CONDITIONS

By R. D. Watts, B.SC. (TECH.), A.M.I.E.E.*

In boiler and furnace installations the efficiency of operation is determined by the combustion conditions. Formerly, the engineer relied solely on visual inspection, and a judgment based on long experience, to regulate the air and fuel supplies to best advantage. This had the merit of being a direct method, although a very subjective one in which considerable reliance had to be placed on the colour-memory of the individual. With the advent of more modern systems of relatively great complexity it has become expedient to control combustion conditions remotely from the boiler. It is no longer possible to make an immediate inspection of the boiler interior after regulating adjustments have been made, and the control engineer has relied increasingly on indirect indications, for example, the change in draught-gauge conditions. This has the disadvantage of a time lag between the regulation and its manifestation. Besides being of importance during normal stable operation, it is of special concern during the closing down of the boiler when a " hot spot " may cause an explosion by re-igniting fuel.

For this reason, attention has been given in recent years to the development of remote-indicating devices which directly monitor the combustion conditions. As a result, instruments operating on television principles and reproducing a picture of the interior of the furnace have been produced: because of the cost of installation and maintenence, however, it is debatable whether such instruments can have a wide appeal. Other instruments making use of photo-electric converters suffer from instability and lack of reproduceability when adequate design precautions are not taken.

The furnace flame indicator described below employs a photo-electric converter as the sensitive element in conjunction with a negative feedback system (British Patents 624641 and 676864). It is simple in design, easy to install and maintain, and operates from the supply mains. Referring to Fig. 1, its operation is as follows. Radiation from a hole in the furnace wall is focused by a lens on the cathode of a photo-electric cell. The latter is of the vacuum type having maximum spectral response at a wavelength of 8,500 Å. With a capacitor, it constitutes a potential divider across the 50 volt winding of a transformer. The control grid of a thyratron is connected to the centre of the divider, and its anode is connected to the 200 volt winding of the transformer. The anode and grid potentials are approximately antiphased under dark conditions, so that the thyratron is quiescent. When the photocell is irradiated, its resistance decreases, causing a change in the amplitude of the grid-cathode voltage and in its relative phase. In each cycle, the thyratron thus fires, passing an average current which is a function of the intensity of the incident radiation. In order that this current shall not be subject to changes in circuit components and in mains voltage fluctuations, an optical-electric negative feedback device is incorporated, consisting of a graded wedge-density filter placed in the path of the incident radiation and moved across it by a moving-coil meter movement. The thyratron current passes through the coil and causes the filter to move so that increased incident radiation is more greatly attenuated. The amplification of the photocell-thyratron combination is so great in comparison with unity, that, by the well-known properties of feedback systems, the characteristics of the instrument are almost entirely determined by the feedback. The law of the wedge-density filter can thus be chosen for any practicable relationship between the thyratron output current and the incident radiation; for many applications it has been found desirable to make the density gradient small for low radiation intensities to make the instrument most sensitive to flame failure conditions.

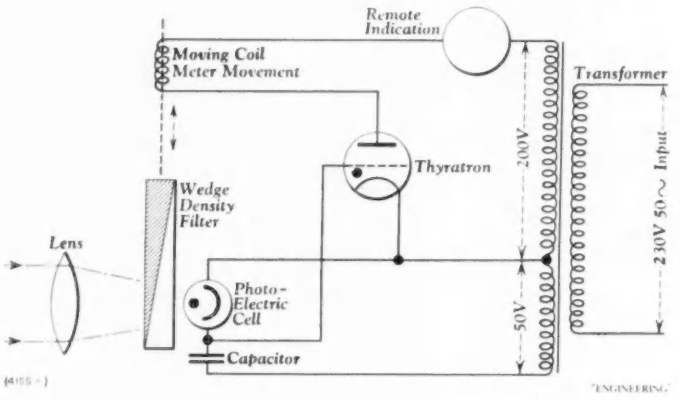

Fig. 1 Circuit diagram of the furnace flame indicator, which employs a photo-electric converter as the sensitive element, in conjunction with a negative feedback system.

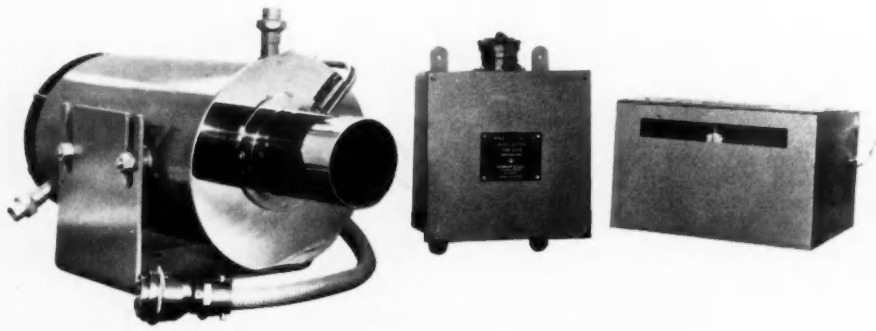

Fig. 2 The pick-up head, control unit and indicator unit of the furnace flame indicator. Instruments of this type are being installed in C.E.A. generating stations.

The output current is available to operate a remote indicator. Since a maximum current of at least 10 mA is available, the indicator may be a robust pointer movement. A special indicator has been developed, however, in which a luminous spot is projected on to a scale, giving excellent visibility even under the most obtrusive lighting conditions. The scale is graded in colours which roughly simulate those within the boiler.

The active element in the indicator unit is a very robust suspended-coil reflecting galvanometer; its period, and the damping of the feedback movement, are adjusted so that rapid fluctuations in the flame are evened out. Any significant changes in combustion conditions are nevertheless registered immediately.

Fig. 2 shows the instrument in the form of three units such as are being installed in generating stations of the Central Electricity Authority. The pick-up head is usually mounted about 4 ft. from the boiler, and is air-pressurised and water-cooled. The indicator unit is designed for mounting behind the control panel, and the control unit, which houses some of the larger circuit components, is sited near the pick-up head.

The adaptability of the instrument makes it suitable for use under widely varying conditions; warning devices can be incorporated. Stability and reliability are such that its use as the initiating element in a servo-system brings the automatic control of boilers a step nearer to realisation.

* H. Tinsley and Company Limited.

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PROPORTIONAL FEED CONTROLLER

Regulating Flows of Materials

Designed primarily for those cases (as in hammer mills) where the rate of feed of material is determined by the power consumption of the driving motor, an automatic control unit has been developed by the 30-98 Company Limited, Gatwick House, Lowfield Heath, Sussex. The instrument can be used with most conventional types of feeder which have a reasonably fine adjustment of the rate of feed, but it is chiefly intended for the vibrating type. The controller reproduces the action that an operator would make when altering the rate of feed. It incorporates a timing device so arranged that when the motor power is below maximum, the feed is increased in steps with a waiting period between each to allow the effect to register on the power consumption. Should an overload occur, the feed is decreased steadily with no waiting periods, until the power has fallen below the set figure. The amount of increase of feed at each step, and the length of the period between the steps, as well as the rate of decrease of feed, can be varied to suit particular operating conditions.

To counteract any transient surges in power consumption, the first stage of the control unit is an integrator which can cover a surge of plus or minus 50 per cent. of the optimum current for any period up to ten seconds. The input current to the control stage is therefore very steady, and close control is possible. The feed can be set to within plus or minus 1 per cent. of the maximum. The controller is designed to operate under extreme conditions of climate, and is sealed against dusty atmospheres. It can conveniently be arranged to operate a reversing motor or two separate single-phase motors, the output being five amperes at 230 volts in two separate circuits. The input signal to the controller can equally well be derived from any mechanism sensitive to changes of fluid-flow, vapour pressure, temperature, light, noise or power consumption.

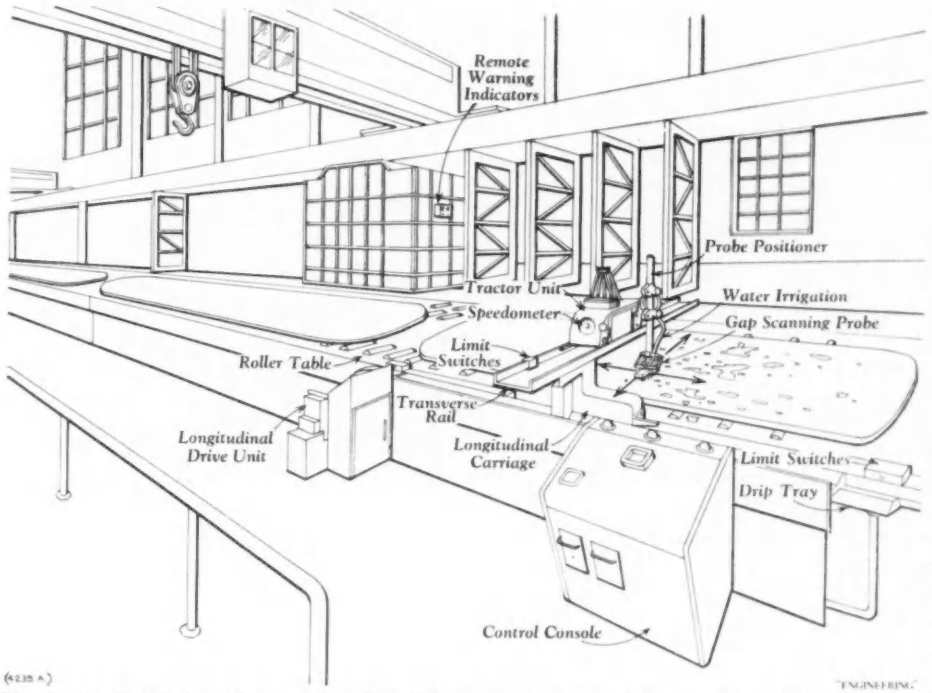


Fig. 1 An impression of a gap-spanning Autosonics installation for the automatic detection of lamination in steel plate.

"AUTOSONICS" FLAW DETECTION

CONTINUOUS-SCAN ULTRASONIC INSPECTION

Continuous quality control of steel plate, light-alloy ingots and forgings, etc., by ultrasonic inspection techniques is now available to British and continental materials suppliers, with the development by Kelvin and Hughes (Industrial), Limited, 2 Caxton-street, London, S.W.1, of automatic ultrasonic flaw-detecting equipment, known as Autosonics. Two outstanding advantages claimed by the manufacturers for Autosonics, in comparison with competitive American and German automatic scanning equipment, are that it can detect flaws to within 0·1 in. of the top and bottom surfaces of the material being tested, and that it incorporates an automatic gain control whereby the echo signal from the inner surface of the material is maintained automatically at a constant level—a feature which, it is stated, is unique to this apparatus.

The electronic circuits which constitute the basis of Autosonics comprise four sections—the flaw detector section, automatic gain control, automatic flaw alarm and recorder, and a system-fault alarm section.

In the flaw detector section the ultrasonic sound pulses are generated. They are transmitted into the material by a probe coupled to the surface of the material by a liquid—either by the contact method, in which the probe is separated from the material only by a thin film of material; by the immersion technique, in which the material specimen is immersed in a tank of liquid and the probe is well separated from the specimen but is acoustically coupled to it through the liquid (a technique that has been used for large-scale applications in the United States, in particular by the Douglas Aircraft Company, Incorporated); or by the "gap" technique, intermediate between contact and immersion scanning, in which the probe is separated from the material specimen by a short distance, the gap being filled with liquid by a continuous irrigation system. This latter technique has the advantage of eliminating the noise and wear associated with contact scanning, and of being simpler to install than immersion scanning equipment which may necessitate very large water tanks.

Fig. 1 shows a scheme for a gap-spanning installation for the automatic detection of lamination in steel plate; and in Fig. 2, a demonstrator is seen setting up the probe for gap-testing steel plate in the Kelvin Hughes research laboratory at Barkingside. A laboratory demonstration set-up for immersion-scanning light-alloy billets is illustrated in Fig. 3.

The pulses reflected from the inner surface of the material specimen and from any flaws encountered are picked up by the probe and amplified in the detector section. The complete sequence of events is presented on a trace or a cathode-ray tube screen.

Initial adjustments are made particularly easy by an unusual method of display on the cathode-ray tube screen; for example, in a single-channel equipment there are two sections of the traces which are brighter than the rest. These bright portions define the position of the electronic "gates" essential to the operation of the succeeding automatic circuits.

The purpose of these gates is twofold: firstly, they select defect indications from all, or only from selected, strata in the cross-section of the material. Secondly, they select only those defect indications which are greater than a preset amplitude.

The automatic gain control section maintains the sensitivity of inspection constant by monitoring the amplitude of a selected echo pulse, and wherever necessary alters the gain of the amplifier to compensate for any change in it.

The automatic flaw alarm and recorder section operates warning lights, bells or Klaxons when a flaw indication is obtained on the cathode-ray tube screen. It can be adjusted to respond to indications from defect signals in any section, or only to signals from separate narrow strata which can be set anywhere in the cross-section. The sensitivity can be adjusted so that it will respond to small or large indications, ignoring those which are less than the present level. Finally, the output from this section can be used to operate various recording systems, e.g., to provide a plan-position indication of any defect present in a plate (Fig. 4).

If the selected monitor signal falls below its control level for any reason, an alarm will operate which will stop the scanning machinery. This alarm will operate until the fault is cor-

Fig. 2 (left) Setting up the probe for gap-testing steel plate on the demonstration equipment installed in the Kelvin Hughes laboratory.

Fig. 3 (right) A laboratory demonstration set-up for immersion scanning of light-alloy billets.

rected, and only then can it be reset. This circuit is a "fail-safe" device, so that if any fault should develop within the circuit, the alarm will operate.

A predetermined scan or search plan is accurately followed by the probe system, thus ensuring that all information relevant to position and size of the defect in the specimen, is indicated and recorded. Selection of the type of scan and recorder is governed by the nature and position of the probable defects, the dimensions and shape of the specimen, and production conditions.

For example, in fixed site testing, material for inspection such as aircraft spars, forgings, etc., is brought to the instruments.

In continuous testing, the inspection instrument forms part of the production line, as for instance, in continuous inspection of strip for laminar type defects. (The set-up illustrated in Fig. 1 is of this nature.)

In sequence testing, components such as small metal blocks used for drop forging, are applied successfully and rapidly to a static probe by mechanical means; and in semi-manual testing, a probe is mounted on a carriage which is propelled, in the manner of a carpet sweeper, over the surface of the material to be tested. In all four cases, automatic recording and marking of the defect can be applied.

The specification of the equipment is as follows: *frequency range*, 0·5 to 10 Mc/s. Frequencies up to 25 Mc/s are available to special order; *inspection range*, up to 25 ft.; *probes*, common, combined or separate transmitter and receiver systems; *widths*, ¼ in. to 6 in.; *pulse lengths*, down to 3 cycles at half-power level; *dead zones*, 0·1 in. at 2·5 Mc/s test frequency for targets equivalent to a ¾ in. diameter flat bottom hole in aircraft type materials; 0·01 in. at 2·5 Mc/s for gross laminar-type defects; *automatic monitoring and flaw alarms*, adjustable from 0·1 in. below top surface to 25 ft., both in location and width; *inspection speeds*, for targets equivalent to ¾ in. flat bottom hole up to 100 ft. per min.; for gross defects up to 400 ft. per min.

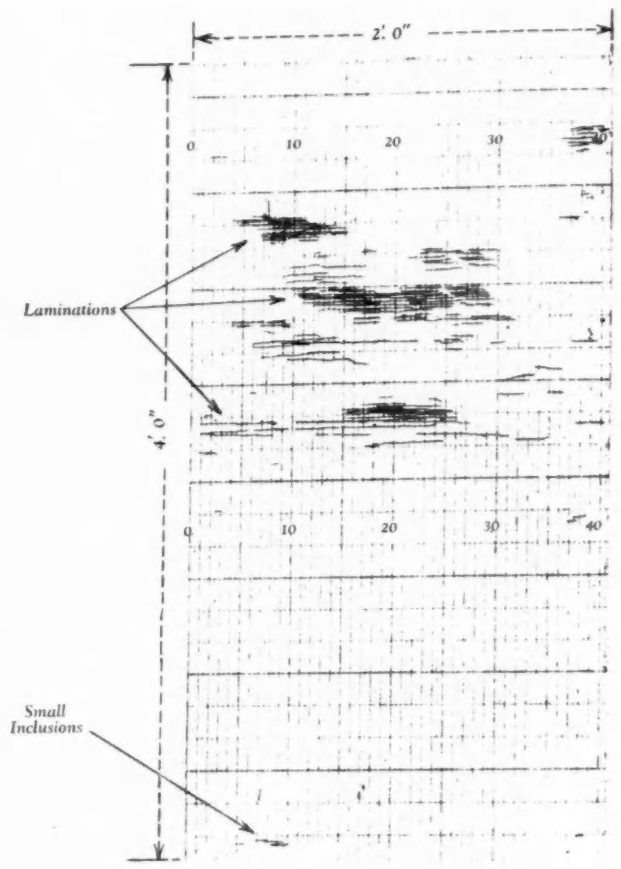


Fig. 4 A plan-position recording taken from a steel plate 4 ft. by 2 ft. by 1 in. showing the plan position of areas of laminations and small inclusions.

THE ROVING EYE

A new version of the Roving Eye has been produced by the B.B.C. As will be seen from the accompanying illustration, the Mark II is equipped with two cameras. The earlier model had only one camera but experience showed that, for independent operation, production techniques are greatly enhanced by two-camera operation. To facilitate movement and parking in crowded city centres, the vehicle length has been reduced by about a foot so that it is now 17 ft. 6 in. long. A modified commercial chassis is used but the body is entirely B.B.C. designed. Vision mixing facilities are available and pictures may be transmitted while the vehicle is moving. When moving, the transmission range is about 2 miles. The aerials used are those shown in the illustration; the Yagi, which broadcasts the vision signal, is controlled by a servomechanism that ensures that the beamed transmission is directed in the desired direction, i.e. towards the nearest relaying point, which may be another vehicle, a connection to the cable network, or a micro-wave relay station. When the vehicle is stationary a telescopic mast may be extended pneumatically from it to a height of 45 ft. to give an extended operating range of about 10 miles.

Vision signals are transmitted from the Roving Eye by frequency modulation at about 625 Mc/s. Sound signals are transmitted on a frequency in Band I. The power supply is provided by a petrol-driven generator.

The Roving Eye Mark II is shorter than previous models and is equipped with two cameras. It carries a 45 ft. telescopic mast.

NOTICES OF MEETINGS

Aslib

LONDON
"Re-classification of the Library of the Institution of Civil Engineers," by H. C. Richardson. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Fri., Mar. 29, 6 p.m.*

Association of Supervising Electrical Engineers

HOVE
"Safety in Electrical Installation," by S. J. Emerson. Brighton, Hove and District Branch. New Imperial Hotel, First-avenue, Hove. Wed., Mar. 27, 7.30 p.m.

Building Centre

LONDON
Films: "Capacitors Pay Dividends" and "Terminated Mineral Insulated Cables," exhibited by British Insulated Callender's Cables Ltd. Wed., Mar. 27, 12.45 p.m.
"Manufacturers' Trade and Technical Literature," by Edward Mills and Ronald Leather. Thurs., Mar. 28, 6 p.m.

Chemical Society

PORTSMOUTH
"Chromatography," by Dr. Tudor S. G. Jones. Southampton Branch. College of Technology, Anglesea-road, Portsmouth. Wed., Mar. 27, 7 p.m.

Combustion Engineering Association

LEEDS
"Application of Back Pressure and Passout Generation," by J. R. Wilkins. Northern Section. Hotel Metropole, King-street, Leeds 1. Thurs., Mar. 28, 10.30 a.m.

Engineers' Guild

LONDON
"The Need for More Professional Engineers," by Dr. Willis Jackson. Metropolitan Branch. Caxton Hall, off Victoria-street, S.W.1. Thurs., Mar. 28, 6 p.m.*

Illuminating Engineering Society

LEEDS
Annual General Meeting and Film Evening. Leeds Centre. E.L.M.A. Lighting Service Bureau, 24 Aire-street, Leeds, 1. Mon., Mar. 25, 6.15 p.m.
LEICESTER
Film Evening. Leicester Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester. Mon., Mar. 25, 6 p.m.

Incorporated Plant Engineers

BIRMINGHAM
Discussion on "Torque Converters." Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Mar. 29, 7.30 p.m.
SHEFFIELD
Annual General Meeting and Film Evening. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Mar. 28, 7.30 p.m.

Institute of Fuel

LONDON
Four papers on Dust Deposition and Atmospheric Pollution, by C. J. Crawshaw and G. England, D. H. Lucas, W. G. Cummings and W. D. Jarvis, and L. G. Austin. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Mar. 27, 5.30 p.m.*

Institute of Marine Engineers

LONDON
"Developments in Marine Electrical Installations, with Particular Reference to Alternating-Current Supply," by A. N. Savage. Tues., Mar. 26, 5.30 p.m.*
"An Introduction to Nuclear Power," by P. T. Fletcher. Lloyd's Register Lecture for Juniors. Thurs., Mar. 28, 5.30 p.m.*
LIVERPOOL
"Control of Steam Temperature in Marine Water-Tube Boilers," by E. G. Hutchings. Merseyside and North Western Section. Junior Lecture. College of Technology, Byrom-street, Liverpool. Fri., Mar. 29, 7 p.m.

Institute of Metals

SWANSEA
Various short papers from members of the Section. Annual General Meeting. South Wales Local Section. Department of Metallurgy, University College, Singleton Park, Swansea. Tues., Mar. 26, 6 p.m.

Institute of Road Transport Engineers

DURHAM
"The Work of the Motor Industry Research Association Proving Ground," by Dr. A. Fogg. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., Mar. 26, 7 p.m.

Institution of Chemical Engineers

LONDON
"The Aqueous Homogeneous Reactor," by R. Hurst. Meeting in conjunction with the British Nuclear Energy Conference. Royal Institution, Albemarle-street, W.1. Tues., April 2, 5.30 p.m.

Institution of Civil Engineers

LONDON
"The Design of Neath and Briton Ferry Viaducts," by R. P. Mears and E. E. Pool; and films on "Construction of Neath River Bridge and Approach Viaducts" presented by J. B. H. Skinner, and "Construction of Briton Ferry Viaduct," presented by A. F. Allen. Road Division. Tues., Mar. 26, 5.30 p.m.*
LOUGHBOROUGH
"Construction of the Hobhole Sluice and Pumping Station," by G. E. Buschner and J. R. Adams. East Midlands Association. Herbert Schofield Buildings, Loughborough. Wed., Mar. 27, 6.45 p.m.

Institution of Electrical Engineers

LONDON
Address by the President, Sir Gordon Radley. London Graduate and Student Section. Mon., Mar. 25, 6.30 p.m.*
Discussion on "The Performance of D.C. Amplifiers with Special Reference to the Use of Transistors," to be opened by K. Kandiah and G. B. B. Chaplin. Joint meeting of the Measurement and Control, and Radio and Telecommunication Sections. Tues., Mar. 26, 5.30 p.m.*
"Earth Electrode Systems for Large Electric Stations," by J. D. Humphries. Supply Section. Wed., Mar. 27, 5.30 p.m.*
BIRMINGHAM
Discussion on "The Teaching of Filter Theory," to be opened by R. O. Rowlands. South Midland Education Discussion Circle. College of Technology, Gosta Green, Birmingham. Tues., Mar. 26, 6.30 p.m.*
CHELMSFORD
Film Evening. London Graduate and Student Section. Public Library, Chelmsford. Tues. Mar. 26, 7 p.m.

FARNBOROUGH
"Frequency-Modulation Radar for Use n the Mercantile Marine," by D. N. Keep. Southern Centre. R.A.E. Technical College, Farnborough. Wed., Mar. 27, 7.30 p.m.
LEEDS
Faraday Lecture on "Nuclear Energy in the Service of Man," by Dr. T. E. Allibone. North Midland Centre. Town Hall, Leeds. Mon., Mar. 25, 7 p.m.
NEWCASTLE-UPON-TYNE
"Earth Electrode Systems for Large Electric Stations," by J. D. Humphries. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Mar. 25, 6.15 p.m.
SOUTHAMPTON
"Flat Pressure Cable," by J. S. Möllerhöj, A. M. Morgan and C. T. W. Sutton. Southern Centre. The University, Southampton. Wed., Mar. 27, 7 p.m.
SPALDING
"The 275 kV Line from Staythorpe to Sheffield," with technicolor and sound film, by J. D. Pierce. East Midland Centre. Masonic Hall, Pinchbeck-street, Spalding. Thurs., Mar. 28, 7.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Civil Engineering Contributions to Shipbuilding," by J. Paton and W. G. N. Geddes. Tues., Mar. 26, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

EDINBURGH
"Testing of Heating and Air Conditioning Plants," by W. C. Ramsay. Scottish Branch. 25 Charlotte-square, Edinburgh. Tues., Mar. 26, 7 p.m.

Institution of Locomotive Engineers

LEEDS
"Simplified Control of a Main-Line Diesel-Electric Locomotive," by C. E. James. North Eastern Centre. Great Northern Hotel, Leeds. Thurs., Mar. 28, 6.45 p.m.
MANCHESTER
"Diesel Locomotive Building and Maintenance," by T. F. B. Simpson. Manchester Centre. College of Technology, Manchester. Wed., Mar. 27, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Some Aspects of Locomotive-Boiler Feed-Water Treatment," by A. J. Parsons and J. S. Hancock. Newcastle Centre. Gas Board Showrooms, Grainger-street, Newcastle-upon-Tyne. Wed., Mar. 27, 6 p.m.

Institution of Mechanical Engineers

LONDON
James Clayton Lecture on "Some Important Problems Concerning the Small Utility Car," by Dr. Ing. D. Giacosa. Automobile Division. Tues., Mar. 26, 6 p.m.*
Discussion on "Are We Satisfied with the Progress of the Diesel Engine for Future Development?" Internal Combustion Engine Group. Wed., Mar. 27, 6.45 p.m.*
"Rotary Shaft Seals: The Sealing Mechanism of Synthetic Rubber Seals Running at Atmospheric Pressure," by E. T. Jagger. Meeting in conjunction with the Lubrication Group. Fri., Mar. 29, 6 p.m.*
BEDFORD
"The Application of Electronic Instruments to Mechanical Engineering," by R. B. Sims and P. Briggs. Eastern Branch. Dujon Restaurant, Bedford. Tues., Mar. 26, 7.30 p.m.

Institution of Naval Architects

LONDON
Spring Meeting:
Annual General Meeting. Presidential Address by Viscount Runciman of Doxford; and "Iron Ore Carriers: Design Considerations," by James Lenaghan. Tues., Mar. 26, 10.15 a.m.
"National Physical Laboratory: New Ship Hydrodynamics Laboratory," by Dr. J. F. Allan; and "Effect of Cavitation on the Performance of a Series of 16 in. Propellers," by Dr. R. W. L. Gawn and Professor L. C. Burrill, at 10.15 a.m.; "Methodical Series Experiments with 0·70 Block Coefficient Forms," Part I by R. E. Blackwell and G. J. Goodrich, and Part II by R. E. Blackwell and D. J. Doust, at 2.30 p.m.; and "Further Sea Trials on the Lubumbashi," by Professor G. Aertssen. (Joint Meeting with the Institute of Marine Engineers), at 3.30 p.m. Wed., Mar. 27.
"Interaction Between a Ship's Hull and a Long Superstructure," by Dr. J. C. Chapman; "Stresses in Deckhouses and Superstructures," by Dr. A. J. Johnson; and "Effect of Superstructures on the Longitudinal Strength of Ships," by Dr. J. B. Caldwell, at 10.15 a.m.; and "Conditions for Unstable Rupturing of a Wide Plate," by G. M. Boyd; and "Ship Hull Pressure Measurements," by Dr. N. Hobgen, Mar. 28, 2.30 p.m.

Institution of Production Engineers

LUTON
Discussion on "Human Aspects of Automation." Luton Section. Town Hall, Luton. Tues., Mar. 26, 7.30 p.m.
MANCHESTER
Symposium on "Application of the Computer in Management Control." Manchester Section. College of Science and Technology, Manchester. Mon., Mar. 25, 7.15 p.m.
OXFORD
Annual General Meeting and Film Evening. Oxford Section. Education Block, Morris Motors Ltd., Hollow-way, Cowley, Oxford. Tues., Mar. 26, 7.30 p.m.
SOUTHAMPTON
"CO_2 Process," by Dr. D. V. Atterton. Southern Section. Polygon Hotel, Southampton. Thurs., Mar. 28, 7.15 p.m.

Institution of Railway Signal Engineers

BRISTOL
"Testing of Signalling Installations," by W. J. Claridge. Meeting Room above Main Booking Hall, Temple Meads Station, Bristol. Fri., Mar. 29, 5.30 p.m.*

Institution of the Rubber Industry

MANCHESTER
"Some Chemical Characteristics of Modern Factice Types," by Dr. C. F. Flint. Manchester Section. Grand Hotel, Manchester. Mon., Mar. 25, 6.45 p.m.

Institution of Structural Engineers

LONDON
"Recent Highway Bridge Construction in Ceylon," by H. C. Husband and K. H. Best. Thurs., Mar. 28, 6 p.m.*

Junior Institution of Engineers

LONDON
"Making Use of Russian and Czech Scientific and Technical Information," by E. Gros. Fri., Mar. 29, 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
"Further Developments of the Hydrofoil Boat," by Christopher Hook. Wed., Mar. 27, 6 p.m.

Manchester Association of Engineers

MANCHESTER
"Nuclear Engineering," by J. Diamond. Engineers' Club, Albert-square, Manchester. Fri., Mar. 29, 6.45 p.m.

Physical Society

LONDON
Annual General Meeting and a Symposium on "Magnetic Recording." Acoustics Group. Royal Institute of British Architects, 66 Portland-place, W.1. Thurs., Mar. 28, 4 p.m. (Tea at 5 p.m.)

Royal Aeronautical Society

READING
"Prospects and Problems in Air Transport," by P. G. Masefield. Great Western Hotel, Reading. Tues., Mar. 26, 6.30 p.m.

Royal Institution

LONDON
"Experimental Demonstrations," by Sir Lawrence Bragg. Fri., Mar. 29, 9 p.m.

Royal Society

LONDON
Various short papers. Thurs., Mar. 28, 4.30 p.m.*

Royal Society of Arts

LONDON
"London Airport," by Sir Alfred Le Maitre (with films). Wed., Mar. 27, 2.30 p.m.

Royal Statistical Society

LEICESTER
"A Review of Some New Techniques," by C. H. Leigh-Dugmore. Leicester Industrial Applications Group. College of Technology, The Newarke, Leicester. Thurs., Mar. 28, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"The Technical Press and the Metallurgical Industry," by F. G. Montfort-Bebb. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Mar. 26, 7 p.m.

Society of Instrument Technology

LONDON
"Process Development and Plant Design: The Role of Instrumentation with Particular Reference to the Application of Computers," by S. T. Lunt. 26 Portland-place, W.1. Tues., Mar. 26, 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

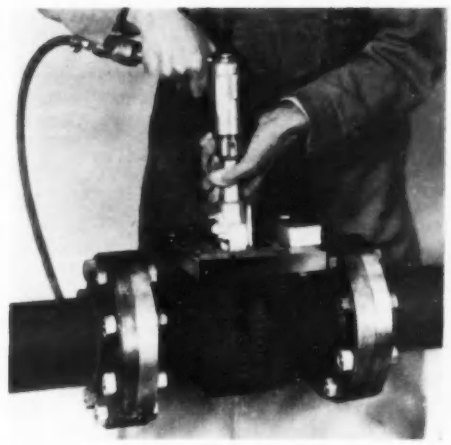
* An asterisk is placed where it is understood that tea is available prior to the time stated.

Aslib (Association of Special Libraries and Information Bureaux), 4 Palace-gate, London, W.8. (KNIghtsbridge 0444.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. J mes', London, S.W.1. (WHItehall 5536.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Railway Signal Engineers, Euston House, Eversholt-street, London, N.W.1.
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. LANgham 4251.)

LAPPING VALVE SEATS IN SITU

A machine for lapping their full-bore parallel-slide valves up to 4 in. in diameter bore has been introduced by Hopkinsons, Limited, P.O. Box B27, Huddersfield. It enables the seats to be lapped without taking the valve out of the pipe line and without removing lid studs from the valve body. These features are in common with the existing machine which deals with valves up to 12 in. bore.

The machine, which weighs 8¾ lb., is driven pneumatically, the air motor running at approxi-



The seats of full-bore parallel-slide valves up to 4 in. bore can be lapped in situ with the Hopkinson portable lapping machine.

mately 2,500 r.p.m.; this speed is reduced by a gearbox to give a final drive at right angles to the main shaft. A driving bit capable of engaging with a lapping plate is provided at this point, and a range of plates is available, each with a suitable slot for the driving bit. A trigger in the hand grip controls the air supply.

As mechanised loading of the lapping plate is impracticable in the smaller range of valve sizes which this machine is designed to service, an adjustable fulcrum plate is provided for fitting to the lid flange of the valve. This plate carries a centre screw which fits into a groove in the machine, and acts as a pivot by which pressure is applied.

The machine operates from a compressed air supply at from 80 to 100 lb. per sq. in., and an automatic push-grip coupling is supplied as a standard fitting, one part being attached to the handle while the other is fixed to the air hose. Breaking this coupling automatically cuts off the air supply.

★ ★ ★

PACKING-CASE HIRE SERVICE FOR RAIL USERS

British Railways are co-operating with Collico Limited, Barking, in the introduction of a new packing-case hire service for traders sending their goods by rail. The new service enables traders to hire the packing cases on a monthly basis from Collico Limited, thus saving themselves the cost of providing or maintaining their own cases. A saving is also achieved in rail costs and so far as senders are concerned only the weight of the contents is subject to rail charges.

The containers are made of metal, are completely collapsible, have no loose parts, and consequently greatly minimise the risk of damage or breakage of the contents. Each container can carry up to two cwt. of merchandise. The cases may carry the client's own advertisement and traders wishing to avail themselves of this service can obtain further details from their local railway goods agent, or from the headquarters of the railway region in which they are situated.

ATOMIC REVIEW

And Furthermore

ONCE the step of building a full-scale atomic power station had been taken, the way was open for further advances. Last year at the World Power Conference, Dr. J. V. Dunworth revealed how by modifications in design, gas-cooled reactor stations little larger than Calder Hall could be built having three times the output; then Calder A was opened and proved a practical success; Mr. R. V. Moore, at the B.N.E.C. symposium on Calder Hall, described the concept of the very high temperature (VHT) reactor; and in December details of the first three privately designed nuclear power stations were released. Refinements to the gas-cooled system have been repeatedly recorded, and now reference has been made to the possibility of building power stations of 1,000 MW capacity. Several lectures have recently been delivered in which potential improvements to the gas-cooled graphite-moderated reactor have been disclosed, together with other details of British progress. Some excerpts from these lectures are published below.

High-Temperature Gas-Cooled Reactors

A change to spherical pressure vessels for power reactors, because of the favourable stressing conditions which can be achieved in this form, and the use by 1968 of working temperatures of 600 deg. C. for the fuel cans, with gas-outlet temperatures of about 500 deg., were forecast by Sir Christopher Hinton when speaking recently in Stockholm on "The Future of Nuclear Power." He was presenting the Axel Axson Johnson Lecture to the Royal Swedish Academy of Engineering Sciences (March 15).

When Calder Hall was planned the maximum can temperature allowed was just over 400 deg. C. with a gas-outlet temperature of 336 deg. C. With to-day's experience, designs could be made for a reactor which would go into operation in 1961 and in which the maximum can temperature could reasonably be put at 450 deg. C. The upward step from to-day's figure was made possible, not by any improvement in the canning material or method of fabrication, or by any improvements in the metallurgy of the uranium fuel elements, but rather by the confidence which experience at Calder had given, and by the development of independent supports for fuel elements instead of stacking the elements one on top of the other. This advance would come therefore by an improvement in mechanical design rather than by advances in metallurgy.

Pressure-Vessel Design

For the design of the pressure vessel, the plate thickness could be stepped up from the 2 in. at Calder to 3 in., though it should be noted that the problems of X-ray examination of welds on site were becoming severe at such thicknesses. It became even more important to watch the notch test of the material as the billet was subjected to very little work and might be expected to show unfavourable characteristics in this respect.

It was probable that a spherical pressure vessel would be chosen for its favourable stress form, but this would require a complete revision of the optimisation parameters of the reactor. The assumed conditions would allow a sphere of 60 ft. diameter or more, giving far larger outputs than the 35/40 MW (electrical) now obtained at Calder. The optimum conditions were probably to be gained by fixing the coolant gas pressure at about 10 atmospheres, so allowing a core diameter which would allow an output of 130 MW (electrical) to be obtained from the reactor. The upward trend of design in relation to the average rating, maximum can temperature and gas-outlet temperature is summarised in the table on the right.

Almost certain, also, was that experience with magnesium, and improvements in its alloys, would allow can temperatures of up to 475 deg. C. to be adopted with confidence. With the use of cylindrical uranium bars as fuel elements, and with to-day's fuel element ratings, the maximum uranium centre temperatures were 600 deg. C. But with current increases in specific ratings, it was likely that these temperatures would rise to 800 deg. C. with the fuel elements in the present form. Uranium suffered allotropic changes at 660 deg. C. and 770 deg. C. and there was an appreciable volume change as the upper temperatures was approached. The uranium centre temperatures predicted were therefore likely to bring about volume changes at the centre which would lead to difficulties and it was probable that a change would have to be made from the cylindrical form of bar to either a small-diameter rod, a flat plate or a tubular element. All these arrangements would increase the weight of canning material per kilogram of fuel and would therefore affect the nuclear physical properties of the reactor unfavourably, almost certainly to the extent of necessitating the use of slightly enriched fuels.

Canning Materials

Directly enrichment of the fuel was accepted —which might be effected by feeding plutonium, from earlier reactors, back into the new system —the cost of the fuel was materially increased and the cost might well prove to be unjustifiable with a canning material which, like magnesium, placed an absolute limit on the can temperature of about 500 deg. C. This would force the adoption of a canning material with a higher melting point.

For use in gas-cooled reactors, the obvious material to choose for canning was beryllium. Zirconium, which was an alternative offering some promise in water-cooled reactors, was unsuitable because it reacted with carbon dioxide at temperatures above 500 deg. C. Beryllium, on the other hand, with its melting point of 1,300 deg. C., reacted hardly at all with reasonably dry carbon dioxide up to temperatures of 600 deg. C. and it did not form any compounds with uranium. It was doubtful whether full advantage could be taken of the characteristics of beryllium as a canning material while using uranium as a fuel, even in the form of thin sections. To gain the full advantage it would probably be necessary to use the fuel in the form of a ceramic or semi-ceramic oxide of uranium.

The development of beryllium as a canning material still presented many problems. Stringent precautions were necessary in handling it because of its toxic properties; metal of a suitable quality was not yet produced in quantity and a great deal of research work was required on fabrication. In fact, it was improbable that reactors using beryllium cans could be in operation before 1963 when we should be achieving maximum can temperatures of about 500 deg. C. and gas-outlet temperatures of some 425 deg. C. This assumed the continued use of uranium as the fuel. Beyond this was the possibility of using uranium in ceramic form, which might raise the gas temperatures by a further 75 deg., to give by 1968 a can temperature of 600 deg. C. and outlet temperatures of 500 deg. C. Such temperatures would probably require a new approach to can design. No longer would the can be a flexible envelope around a rod of fuel, supported by its own strength; external support would be necessary, either from the wall of the can or by other means.

—	BEPO	Windscale	Calder Hall	To-day's design
Average rating, MW/T	0·15	0·75	1·4	2·0
Max. can temperature, deg. C.	200	300	408	450
Gas outlet temperature, deg. C.	90	211	336	380

The advance of the bulk gas-outlet temperature is shown in the illustration below, Fig. 1, and the previous arguments allowed the extrapolation of the curve over the 1968-70 period. There was no doubt that the higher temperatures that had been predicted would be attained, though, at present, it was not possible to say how this would be done. Such temperatures would introduce serious problems in the design of the pressure vessel, but the difficulty could be overcome by the use of double-skin vessels with intercooling, so arranged that the outer skin was not subjected to unreasonable temperatures. (See Atomic Review, February 15.)

Extended Surface and Choice of Gas

A further compromise would also have to be made with the design of the extended surface of the can; its heat transfer characteristics could be improved by adding to the metal in the fins, but this adversely affected the neutron economy of the core. Though a greater rating of the elements could also be obtained by forcing through a larger mass of gas, this would involve more power in the circulators. Other gases than carbon dioxide could be used with advantage. The choice of carbon dioxide had been made because of its adequate properties of heat capacity and neutron economy, and because it was cheap and readily available. Helium would require lower circulating power and its complete

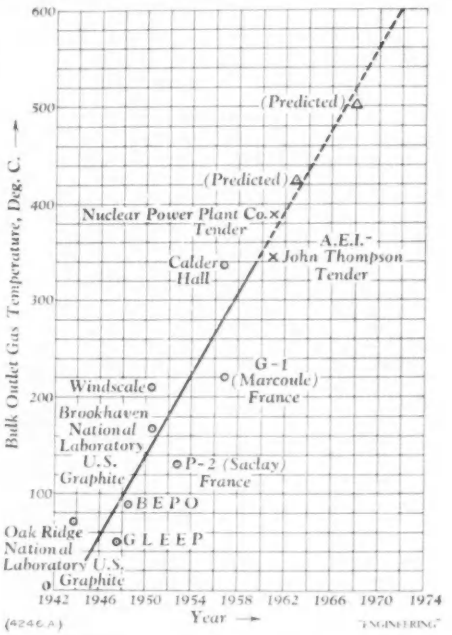


Fig. 1 The increase over the last ten years in the bulk gas-outlet temperature in gas-cooled power reactors. The curve is extrapolated into the 1970's.

inertness would remove some anxieties arising with design at the higher temperatures and pressures being considered; unfortunately, bulk supplies were obtainable from only one source overseas.

Hydrogen, easily available, would require only one-sixth of the circulation power required for the same mass of carbon dioxide and would therefore admit the possibility of using higher mass-flow rates. But, on the other hand, it formed a pyrophoric compound with uranium within a certain temperature range and its embrittling effect on steel was another disadvantage; neither of these difficulties, Sir Christopher remarked, was necessarily insuperable.

Cottrell Effect

Sir John Cockcroft has recently discussed the technical advances made since the completion of the Calder Hall design; firstly before the Oxford University Scientific Club on March 5 (Boyle Lecture), and secondly in a Parliamentary

and Scientific Committee address delivered on March 12. Some points from these talks are given below.

During the first six months of operation at Calder Hall, only two faulty elements in 10,000 were found and the faults could hardly be seen on inspection. The main fault occurring in the fuel elements was due to a new effect, predicted by Dr. A. H. Cottrell, which is now known as the "Cottrell effect." Dr. Cottrell predicted that when uranium is traversed by the fission fragments, which are high-speed heavy atoms, it leads to the production of local stresses in the uranium crystallites. As a result of this, if the uranium bar is under load, at a temperature of 100 deg. C., creep will occur at stresses 100 times less than are required to produce the same creep rate normally. This was verified by making springs of uranium metal and loading them in the BEPO reactor. The springs were found to extend much more under irradiation. Since the bottom fuel elements of the reactor are stressed by the load of all those above, they tend to bow like a strut. The normal thermal creep would not have been troublesome; the creep induced by radiation however is larger, and it has been verified on shutting down the first reactor that the Cottrell theory is largely correct. This can be remedied in the Calder Hall reactors by fixing intermediate supports to the fuel elements, so that the effective strut length is reduced. In future designs, the weight of the fuel elements will be carried by the graphite. In this way it is hoped that the fuel elements will be able to remain in a reactor for the 1,500 days of full-power working, which is their expected useful life.

Gas Leakage

At present about 2 tons of carbon dioxide is lost a day from valve spindles, glands and joints in the Calder Hall A station. It is being reduced by conventional engineering methods and is not costly, but it emphasises that the testing standards required for high vacuum equipment will be necessary. These can be achieved.

Initial Power Stations

Two of the designs adopted for Britain's first civil power stations have spherical pressure vessels about 70 ft. in diameter; the third will use cylinders 50 ft. in diameter, compared with the 37 ft. diameter vessels at Calder Hall. As a result the uranium metal in two reactors has been raised from about 260 tons at Calder Hall to 500 tons in one of the new designs.

Power Station Prospects

It is anticipated that the second generation of stations will have capital costs per kilowatt some 20 per cent. lower than those of the initial stations, which are about £120 per kW. More radical changes in design would enable a third generation of reactors to employ fuel-element temperatures in the region of 600 deg. C.—a rise of 200 deg. C. above those immediately envisaged. A number of major developments in technology would be required. As stated, above, fuel-element sheaths would be made of a heat-resisting material such as beryllium, beryllium alloy or some other alloy instead of magnesium alloy. Secondly, carbon dioxide reacts with graphite to form carbon dioxide, and the reaction is promoted by both heat and radiation. At present this effect is not serious but it will be necessary to ensure by loop tests in BEPO and DIDO that it does not produce difficulties at higher temperatures. Finally there is the problem of producing a uranium fuel to withstand the higher temperature. In addition to the allotropic changes mentioned above uranium metal swells at 600 deg. C. due to accumulation of the fission gases krypton and xenon. So to reach 600 deg. C. ceramic fuels may be necessary. The Atomic Energy Research Establishment at Harwell has worked on this for two years—as a preliminary to technological development by the U.K.A.E.A. Industrial Group.

It may also be an advantage to use flat plates or other shapes for fuel elements to give increased heat dissipation, but since this would also result in higher neutron losses, some fuel enrichment would be required. If a temperature of 600 deg. C. can be achieved then it might be possible to generate 400 MW from a single reactor, giving a total output of 800 MW for a two-reactor station. Thus the 1,000 MW station is already in sight. It follows that fewer sites would be required, but owing to the large cooling water demand (which would also be the case for large conventional stations), siting would be limited to coastal and estuary areas. Ceramic fuels may subsequently lead to the use of operating temperatures of the order of 800 deg. C. and an advanced design based on this principle is being studied at Harwell (see ENGINEERING, December 7, page 725, 1956).

Marine

Further news concerning the use of nuclear reactors for marine propulsion has recently been published. Previous notes on this subject have appeared in Atomic Review on February 1, January 4, 18 and 25 and in 1956 on August 25.

Nuclear Powered Merchant Ships

A committee will be set up under the chairmanship of the Civil Lord of the Admiralty (Mr. T. G. D. Galbraith, M.P.) to consider the application of nuclear power to merchant ships and to watch over the general health of the shipbuilding and marine engineering industries. Such a step is necessary, for it is known that a number of nations, including Norway, the United States, Japan, and France, are interested in merchant shipping powered by nuclear means, and as soon as atomic power becomes competitive in this application it is essential that British shipbuilders should be in a position to meet orders.

Since the pressurised-water reactor as used in Nautilus is uneconomical it has been suggested that a gas-cooled ractor of the Calder Hall type may be used to propel a merchant ship, though work is in progress on the organic liquid moderated system for marine propulsion. The large size of such a reactor makes it probable that the vessel powered by one would be an oil tanker of about 80,000 tons, costing between £10 and £12 million. It is understood that the project would be wholly or largely Government financed. It could be completed in about 6 years.

The concentrated weight of the reactor would also require that it be located amidships and that the pressure vessel be built as part of the hull. In designing the shielding equipment it would be necessary to allow for the possibility of the ship being sunk in mid-ocean. It would be essential in these circumstances that the radioactivity decay to a safe level before corrosion exposes the fuel elements. A tentative estimate suggests that the first cost of the reactor, including the cost of research and development, would be one and a half times the cost of the hull. The hull would probably cost £50 per ton.

Nuclear Powered Submarine

Vickers Nuclear Engineering, Limited, is now able to announce that since the formation of the company in February, 1956, they have been engaged on an Admiralty project to design and develop a set of nuclear machinery suitable for installation in a submarine, and that good progress has been made. The company, which consists of Vickers-Armstrongs Limited, Rolls-Royce Limited and Foster Wheeler Limited, is developing a propulsion unit based on a pressurised water reactor; a similar type of reactor is used in the U.S.S. Nautilus.

Although the work is shared between the three firms, all designs are agreed by the three before submission to the Admiralty. Rolls-Royce Limited are responsible for the design of the reactor and associated equipment, Foster Wheeler Limited the steam generators and related plant, and Vickers-Armstrongs Limited the turbines, condensers and other auxiliaries. The company has permanent representatives stationed at the A.E.R.E. Harwell as part of the Naval Section, which is a team of Naval Officers led by a Captain. These representatives obtain from the A.E.A. information on nuclear matters required by the company's design staff. The many experimental facilities in the establishment are available to confirm the calculations made by the companies' engineers and scientists.

The prototype machinery will be installed in a land-based hull structure, which is to be the responsibility of the U.K.A.E.A. There the machinery will be proved, and tests and trials carried out. It will also be used to train personnel. The machinery is designed for a submarine of high speed with very great range, and will enable it to remain submerged for long periods, since there will be no need to recharge batteries every 24 hours as in conventional submarines. The name "Dreadnought" has been approved by H.M. The Queen for Britain's first nuclear submarine.

Nuclear Warship

The United States Navy has announced that the construction of an atomic powered surface ship will be started this year and is scheduled for completion in late 1960. The ship, which will be named "Long Beach," will be the first American surface warship to be equipped with a main battery of guided missiles as well as with a nuclear power plant. She will be built in the yards of the Bethlehem Steel Company, at Quincy, Massachusetts.

Also announced is the awarding of contracts totalling £4 million for the main propulsion machinery for the first nuclear powered aircraft carrier and for five more nuclear submarines. Two companies receiving contracts are Westinghouse Electric and General Electric. Five nuclear powered submarines should be part of the U.S. fleet by the end of 1958.

Admiral for Nuclear Propulsion

The Admiralty has announced the creation of a new post of Rear-Admiral Nuclear Propulsion. This officer will act as the focus within the Admiralty of the operational and material aspects of nuclear propulsion, and will keep in touch with developments in the field of nuclear power by the Atomic Energy Authority and by industry. He will also be the link in these matters between the Admiralty and other Government Departments, Ministries and Services, and between Commonwealth and foreign navies. The appointment will be filled by Rear-Admiral G. A. M. Wilson, who will be responsible to the engineer-in-chief of the Fleet.

Abstracts of Overseas Reports

Long abstracts of German and American papers on the marine application of nuclear energy appeared in the February issue (vol. 12, No. 2) of *The British Shipbuilding Research Association Journal*. One paper (Finkelnburg, *Hansa*, vol. 93, page 2456, 1956) gives some major considerations in the use of reactors in ships as follows. A ship reactor must be built to withstand greater load variations, stresses, and vibrations than a land plant. Effective shielding must be provided even if it means a large increase in cost; the author considers that this factor is often underestimated in economic analyses. The consequences of a collision or other mishap must also be considered. Moderators and cooling media must acquire the least possible radioactivity during normal operation; pure water meets this requirement. The fissile materials must be in such a form, and the fuel elements so designed and arranged, that they will resist the corrosive action of sea-water for the greatest possible time. The escape rate of fission products through damaged sheathing must be slow. These requirements are best met by uranium dioxide in stainless-steel sheaths. It is considered that the pressurised-water reactor is the only heterogeneous type which can be safely employed in ships. It may, however, prove advantageous to use homogeneous reactors working with a liquid alloy containing enriched uranium and bismuth. Uranium in this form is much more easily and economically handled.

In the event of a leak the alloy would solidify, thereby minimising contamination; the alloy selected should have good corrosion resistance in sea-water.

The need for a rigid reactor structure and consequent hull strengthening is discussed in a second abstract (K. Illies, *Hansa*, vol. 93, page 2458, 1956). The author discusses the propulsion machinery for a nuclear propelled tanker, having a speed of 16 knots, a length of 590 ft., a deadweight capacity of 22,000 tons, and a geared steam turbine of 10,000 s.h.p. at 105 r.p.m. The whole of the primary circuit, including the pressurised-water enriched-uranium reactor, heat exchangers, and water-circulation pumps, is placed within a horizontal cylindrical pressure-tight shield 41·3 ft. long, 31·5 ft. in diameter, and 2·36 in. thick. The air in this compartment is specially filtered and cooled. The weight of the shield plus contents is about 900 tons. This concentrated weight is supported by exceptionally sturdy construction in the corresponding part of the afterbody. The compartment is secured at the forward end and rests on bearers which are between 5·9 and 8·2 ft. deep. It is protected on either side by bulkheads consisting of oak planks between steel walls. The additional structural weight, compared with a conventional ship, amounts to 300 tons. The reactor itself is cylindrical, and is placed vertically near the forward end of the shielded compartment. It is 5·57 ft. in diameter and 18·3 ft. high, and is surrounded by a shield 31·5 in. thick; this is constructed from a lead compound, with organic fillers. The reactor core contains 2·4 tons of nuclear fuel, together with the usual control rods; the whole core is attached to the lid of the pressure vessel, forming a single removable unit. The reactor can be removed for refuelling or overhaul through a large manhole, in the top of the outer shield. This is surrounded by a watertight shaft of greater diameter, which extends upwards to deck level and during these operations is filled with water. When the reactor-core unit has been lifted clear of the outer shield, it is displaced horizontally into a lead container which is normally kept in readiness at the bottom of the shaft, just aft of the manhole. The container is then sealed and lifted ashore. The nuclear plant is estimated to have a thermal efficiency of 0·221 as against 0·253 for a conventional plant. The weights are respectively 2,000 and 1,100 tons, but the additional and varying weight of fuel oil must be taken into consideration for the second case.

Shield configuration is discussed in an American paper (O. H. Klepper, U.S.A.E.C. report NNSD-NSPS-1008, 1956), in which four hypothetical nuclear propelled ships are compared. Nuclear ships are shown to have greater load carrying capacity than oil-fired ships but this must be balanced against higher capital cost. It appears from this study that a dense and compact shield such as lead is best for dry-cargo ships in terms of revenue. From a weight and space point of view the oil tanker seems better suited to liquid shielding since the cargo tanks can be used to some extent for this purpose.

The use of the organic moderator diphenyl for ship-propulsion reactors is treated in a second American paper (G. Leppert, *J. Amer. Soc. Nav. E.*, vol. 68, page 633, 1956). In a design prepared under contract by a United States company, the coolant, diphenyl, is expected to have a temperature of 530 deg. F. (277 deg. C.) at the reactor outlet, and the system pressure is to be 300 lb. per sq. in. The possibility of avoiding high pressures (2,000 lb. per sq. in.), as are needed in the pressurised-water reactor, for example, is a strong inducement to the development of this type of reactor. Diphenyl contains hydrogen, carbon, and oxygen, and will be quite effective as moderator. Its disadvantage is a flash point considerably below the operating temperature of the reactor, so every precaution will have to be observed to prevent the escape of hot fluid into the atmosphere.

Soviet Icebreaker

The turbine for use in the Soviet 16,000 ton nuclear powered icebreaker Lenin has been completed at the Sergei Kirov works in Leningrad and is being tested. The vessel is expected to be launched in November this year and will make its maiden voyage in 1958. It is to be a combined cargo and passenger carrying icebreaker for service in the arctic seas north of Russia.

General Notes

Fast-Slow Reactor at Harwell

Harwell now has a fast-slow reactor, a simple modification having resulted in interesting changes to the characteristics of the fast reactor ZEPHYR. Graphite has been substituted for the uranium bars that originally formed the outer reflector. The thin inner reflector of uranium still surrounds the plutonium core. In its new form, the reactor diverged with a critical mass of plutonium very close to that in the uranium reflected system. Because the neutrons reflected back into the inner reflector have been slowed down, ZEPHYR now shows some of the characteristics of a thermal reactor. For instance, experiments have shown that the chain reaction can now be controlled, as in a thermal reactor, by putting an absorber of slow neutrons such as cadmium into the graphite. It is too early to predict the applicability of this mixed system to power breeder reactors such as that at present under construction at Dounreay. We have already referred to the American fast-slow reactor ZPR-5 in Atomic Review (February 1 and March 1), and hope to publish a full description in ENGINEERING shortly.

ZEPHYR, which was Britain's first fast reactor, became critical for the first time on February 5, 1954, and its name is derived from the initials of its title Zero Energy Fast Reactor. In August, 1955, it was announced that in this pile Harwell scientists had succeeded in creating two atoms of plutonium for each atom of plutonium consumed. In a full-scale fast reactor fuelled with plutonium, the breeding gain might be rather less, say 1·6 to 1·7. The fast-breeder reactor now building at Dounreay may eventually use plutonium as fuel.

Organic Moderator

Favourable reports have been published on isopropylbiphenyl as an organic moderator for reactors. It is being supplied in pilot-plant quantities by the Monsanto Chemical Company of St. Louis, U.S.A.

Fig. 2 Eight-unit AB.18 cock manifold made by Richard Klinger Limited. One cock is shown dismantled. Similar units are fitted at the Calder Hall nuclear power station.

Cock Manifolds at Calder Hall

Three-way cocks ganged together in the form of an 8 unit cock manifold arranged in two groups of four as shown in Fig. 2, are made by Richard Klinger Limited, Sidcup, Kent, for use in gas-cooled reactors. A considerable number are already in use at Calder Hall. The Calder Hall reactor is divided into eight areas, each of which is controlled by a 54 point gas sampling plant. From each area 212 sampling pipelines are led through the Klinger manifold cocks which reduce the number of channels to 53. The sampling pipes are welded into the manifold cock bodies and these are mounted on the same framework as a 54 way rotary selector valve. The selector valve is connected via a cooler and filter to a chamber in which is housed a precipitation unit and radiation detection gear. This reveals the presence of any radioactive gases that may have leaked into the carbon dioxide system, and the source of the leak can then be traced by testing gas taken from each sampling cock separately. Each cock is sealed by a renewable sleeve of compressed asbestos which is located around a parallel plug with a lapped finish. Stainless-steel eyelets in the sleeve protect the packing from the action of the passing fluid. The position of the eyelets is fixed by means of a ridge on the outside of the packing sleeve which fits into a corresponding groove in the body. The illustration shows an 8 unit A.B.18 cock manifold with one cock dismantled. The split ring fits into the groove at the bottom of the plug and locates it firmly in an axial direction when the compressed asbestos packing sleeve is forced against it by means of the tightening nut. The body and the plugs are made from wrought stainless steel. In order to prevent the risk of any leakage, each group of four cocks is covered by a sealed bonnet, which is only removed when the cocks are to be operated. Evidence of the satisfactory working of these cocks was disclosed recently when one of the reactors at Calder Hall was closed down in an endeavour to trace a leak of carbon dioxide. In the course of the tests all the Klinger cocks on the reactor were proved to be free of blame.

Atoms and Health

The problem of locating nuclear power stations underlines the importance of reassuring the public on nuclear matters, and to this end an "Atoms and Health Exhibition" is being held at the premises of the Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1, until May 31. Opening the exhibition, Lord Salisbury said that in 11 years of operations in this country, there had been no case of an atomic energy worker exceeding the safe dose, and no incident of detectable injury from external exposure. He also noted from a Medical Research Council report the following statement: "We believe that nuclear energy might make power available at a lower cost in accidents, illnesses and disability than that incurred in connection with other sources of power." Care is of course necessary, but few informed people will doubt that the controlled application of nuclear power is possible in complete safety. Doubts arise where its uncontrolled and unpredictable use is envisaged, as in test explosions. The exhibition includes working models and diagrams and examples of protective and remotely-operated devices.

Reactor Engineering

At the third British Thomson-Houston Summer School, held last July, the proceedings of which have recently been published, Mr. D. F. Welch (seconded by B.T.H. to the A.E.I.-John Thompson Nuclear Energy Company), speaking on "The Function of the Engineer in the Field of Nuclear Energy," said that "Reactor work is 90 per cent. engineering, of which probably 80 per cent. is mechanical or thermodynamic . . . provided an overall basic engineering to a fairly high standard has been given, the electrical engineer is likely to be better suited to reactor development than the mechanical engineer."

In Parliament

LORDS LOOK AT ATOMIC POWER

Many problems concerning the development of atomic energy came before each of the two Houses of Parliament last week. In the Commons, difficulties were discussed by means of question and answer, while, in the Lords, there was a debate based on the selection of sites for atomic power stations.

Opening this debate, Lord Lawson (Labour) said he fully appreciated the work of the Atomic Energy Authority and the Government's resolve to apply atomic energy for peaceful purposes, but he had felt for some time that decisions being taken by the Authority made it look as if the servant of Parliament was in danger of becoming the master. It had been decided to site these stations in the more remote areas, where some of them would conflict with the National Parks Act, and not in built-up industrial districts, such as those parts of the country where coalmining, heavy engineering and steel making were concentrated.

Following the re-rating of industry, roads would play an even more important part than hitherto in the location of new factories and he could not see industrial organisations overlooking the areas where the atomic power stations were being placed. In some built-up industrial districts, such as West Durham where the coalfields were becoming depleted, employment prospects were likely to become limited. One of the dangers of the Authority's decision, therefore, was that it might be necessary to move whole communities to other parts of the country. Sites for new power stations should be chosen nearer to where the power would be required.

The view was expressed by Lord Rea (Liberal) that if Calder Hall atomic power station had been placed in a depressed area, only a few miles north of where it was now situated, a great deal of ugliness would have been replaced and the station would be of even greater value to the country. Officials in the Government Departments and municipal bodies who had the responsibility of granting or withholding planning authority were frequently placed in a most difficult position, in that they were confronted with what amounted almost to a *fait accompli*, and that they found that the various aspects of the projects had already been arranged.

ATOMIC POWER PLANT FOR WALES

The view that there were four principal considerations to be taken into account in determining the siting of new atomic energy works, was expressed by Lord Hylton (Conservative), the next speaker. The first of these, he said, was their proximity to areas where there was an unsatisfied demand for electricity, and where generation from coal would be costly owing to the distance from coalfields. Then there was the need for foundations suitable for supporting the heavy weights and shields required by the reactor. That position did not arise everywhere.

There must be access to large volumes of cold water for condenser cooling. He understood that about 25 million gallons of cold water an hour were needed. The water was taken from the sea, or a river estuary, and returned there heated to some 15 deg. above the normal sea temperature. Finally, the area selected must have a low population density, owing to the Government's policy that these stations must be placed at a distance from centres of population until more experience regarding the safe operation of atomic power works was obtained.

Viscount Hall (Labour) said that the country was facing a new industrial revolution and, whatever the cost might be, Parliament should see that the beauty of the countryside was safeguarded. Water was not carried by overground piping, however far it had to be taken, and the whole question of transmission lines and pylons should be reviewed. The extra cost would be small compared with the total estimated cost of £1,460 million which the nuclear power plan would involve. He ended his speech with a plea that at least one atomic power works should be built in Wales.

On this point, Lord Mills, the Minister of Power, who replied, gave an assurance that it was the intention to erect one or more stations in the Principality, provided that suitable sites could be found. He said that the Government had determined that these power stations must be placed away from built-up areas. It was not that they were thought to be in any way liable to accident, but because they contained highly toxic materials and represented a new development which had not stood the test of operation on a large scale. The procedure for finding sites, having consultations with all concerned, and holding public inquiries took nine months on the average, but, on occasion, that period had been doubled. The time limits imposed by the Statutes must be followed but they should not be exceeded.

He was not sure that power stations were the ugly things they had been said to be. To ensure that their general design and main architectural features were not incongruous in the landscape, the Central Electricity Authority referred these matters to distinguished architectural consultants, and invited the comments of the Royal Fine Art Commission.

AIDING EURATOM

In the Commons, Mr. Reginald Maudling, the Paymaster-General, informed Mr. John Hynd (Labour) and Sir James Hutchison, Bt. (Conservative) that the Government favoured co-operation in atomic energy matters between the United Kingdom and Western Europe, including those countries which were forming Euratom. The United Kingdom and the Euratom countries, together with other Western European countries, had been working out practical measures for some time in the Organisation for European Economic Co-operation.

The United Kingdom Atomic Energy Authority had recently held technical discussions with representatives of Euratom countries on the part which gas-cooled reactors, of the type ordered by the national electricity undertakings for installation in the United Kingdom, might play in the Euratom nuclear power programme. As announced in a joint communiqué on March 1, the Authority had offered to facilitate contacts between United Kingdom and European firms, and to assist in training engineers and scientists from the countries concerned. United Kingdom experts would continue to examine the proposed Euratom power programme.

Mr. Maudling added that he understood that the Euratom treaty had not yet been signed. When that organisation had been formed, the Government would know more about it and would be able to state more clearly what their attitude towards the organisation would be.

TENDERS FOR ATOMIC POWER WORKS

Tendering for the construction of new atomic power stations, Mr. Maudling informed Mr. Albert Roberts (Labour), was a matter for the electricity authorities. He understood, however, that these authorities intended to place contracts on the basis of the widest possible competition. Mr. William Warbey (Labour) suggested that the production division of the Atomic Energy Authority had a great and successful experience in the building of these stations, and should be encouraged to tender. Mr. G. R. Strauss (Labour) pointed out that the Ministry of Works had built all the atomic power stations in the past. He considered that that Ministry should tender. Mr. Maudling said that it was not possible to talk about building large commercial nuclear power stations on the basis of what had happened in the past because it had not happened in the past. He understood that there were four groups in the market for the manufacture of these projects. Other commercial groups were being formed. That was sufficient, he thought, to provide a very active range of competition for the construction of these stations, bearing in mind that a start was being made upon a completely new industry and on a very large scale.

MEETING THE NEED FOR AIRCRAFT

Mr. George Brown (Labour) questioned the Minister of Supply about the capital equipment transferred by the Government to various aircraft companies. He was told by Mr. Aubrey Jones that the value at cost of capital equipment, inclusive of buildings, supplied by his Department for aircraft development and production since the beginning of the financial year 1951-52 amounted, in round figures, to £100 million. Payments received by the Department from the firms concerned, in respect of this equipment, would total about £20 million by the end of the present financial year.

Mr. A. E. Hunter (Labour) wanted to know what consultations the Minister had been having with British aircraft manufacturers with regard to meeting the future needs of the British Overseas Airways Corporation and British European Airways for new airliners. The answer given by Mr. Aubrey Jones was that he was in close touch with a number of aircraft companies and, of course, with the Minister of Transport and Civil Aviation.

CIVIL WORK AT ORDNANCE FACTORIES

There were serious difficulties, Mr. Aubrey Jones said, in the way of changing the Royal Ordnance Factories over to the manufacture of civil goods on a larger scale. He assured Mr. George Brown, however, that some work of this character was being, and would continue to be, undertaken by these factories.

The case of the ordnance factory at Dalmuir was taken up by both Mr. J. Rankin (Labour/Co-operative) and Sir James Hutchinson, Bt. (Conservative). Sir James was informed by Mr. F. J. Erroll, the Parliamentary Secretary to the Board of Trade, that the amount of defence work was declining and that there was also likely to be less work of that kind coming from other countries. If there ceased to be enough defence work to maintain the Dalmuir factory, the objective of the Board of Trade would be to secure a suitable long-term use for it. There was a good hope, if and when the factory was no longer needed for defence purposes, of finding an industrial undertaking that would provide continuity of use and increased employment, and that the changeover would be made in a way likely to cause the least possible disturbance.

Mr. John Maclay, the Secretary of State for Scotland, referred Mr. Rankin to the reply by Mr. Erroll and said that he had been in close touch with both the Minister of Supply and the President of the Board of Trade regarding the factory. Mr. Maclay added that he had so informed the County Council of Dunbarton, the Corporation of Glasgow, and the Clyde district committee of the United Society of Boilermakers, Shipbuilders and Structural Engineers, from whom he had received representations.

Safety at Atomic Power Plants

There was no possibility, Mr. Maudling said, of an explosion resembling that of an atomic weapon occurring as a result of accident or malicious damage to plant or laboratory equipment in any atomic energy establishment. He told Mr. Hector Hughes (Labour) that in all instances where substantial quantities of radioactive materials were handled, very great care was taken to prevent any significant release of radioactivity as a result of fire or accident of any kind.

Technical Education in Scotland

In answer to Mr. W. W. Hamilton (Labour), who urged that the extension of technical education facilities should be speeded up, Mr. Maclay said that, in planning the development of these facilities, account was being taken of the needs of the nuclear power programme. The Government were doing all they could to hasten both the provision of new colleges and the extension of the work of existing colleges.

THE HUMAN ELEMENT

One Boss on the Shop Floor

Only 50 years ago in the greater part of British industry the foreman bought his own materials, arranged his work, employed and dismissed his labour, set his own rates and designed his own tools. He was "all supreme and his authority unquestioned." These words were spoken by Mr. A. W. Waring, managing director of Joseph Lucas Limited and president of the Institute of Industrial Supervisors, at a regional conference of the Institute last year. He added that after a period of decline during which the onset of "scientific management" made the foreman's position confused, it was now becoming clear that "the principle of one boss on the shop floor is as necessary now as it ever was." Many other speakers argued that the foreman is an essential part of live management and is there to make workers want to do a job, to tell them and show them how it should be done and to see that they do it. The specialist's function is to advise, not to give orders.

The proceedings of the regional conferences are published by the Institute under the title "The Future of the Foreman." Many well-known people in industry and education for management took part, as well as consultants, trade unionists and foremen. Among the views put forward was that "the present general standard of management in industry is lamentably low"; that a foreman should always get a salary at least 25 per cent. higher than any of the highest paid men under him; that the average worker needs, for his own satisfaction, to complete a task, for approval, for psychological security, and for constructive and creative activity. The qualities most valued in people in authority are consideration, forcefulness, justice and knowledge of the work; those most disliked are pettiness, indecision, lack of sympathy, bad temper, favouritism and victimisation, lack of appreciation and inaccessibility.

Peace for the Wicked

We are not, it appears, to be allowed to buy our sixpenny-worth of happiness. In the United States, we are told, one can buy "tranquilisers" like aspirins or sweets. Everyone takes them, whether in Washington, Hollywood, or Harlem. Yet the World Health Organisation labels them as dangerous drugs, potentially habit-forming. The Committee on Addiction-producing Drugs say in their seventh report that "tranquilisers" or "ataraxics" (ataraxia means serenity of mind) are in such rapidly increasing use that it has become "a source of concern in several countries." These drugs resemble the barbiturates, say the Committee, and should be subjected to national control.

It is hard to believe that as soon as a means is found to effect cheaply (and safely, say some experts) a radical improvement in the sense of well-being—by promoting sleep or relieving anxiety—those concerned with world health should advise a ban because it is "habit-forming." Perhaps it is that the only worthwhile peace of mind results from having overcome anxiety, insomnia and misery. But a habit of well-being and serenity is not to be despised whether through pills or, fakir-fashion, through spikes.

To Each His Own

Much was said during the four days of the public inquiry into the Briggs dispute that has cleared the air and exposed some of the roots of the trouble. On the last day Mr. L. V. Blakeman, labour officer at Ford's, read the company's reply to the trade union case put to the Court the previous day by Mr. C. V. Berridge, of the A.E.U. executive council.

Mr. Berridge accused the management of "implacable hostility" towards the trade union movement and towards the A.E.U. in particular. Mr. Blakeman replied that the root of the trouble was "a group within the highly organised, powerful and financially strong body of shop stewards whose objective is destructive conflict, and whose persistent activities make impossible the normal give and take of factory life." Mr. Beard, for the unions, replied that the McLoughlin incident "was a symbol of a great deal that happened at the plant." The Court heard that the shop steward's convener spent 26·5 per cent. of his time working as a jig and tool maker, the rest on trade union business.

The following profile of the shop steward by Ferdynand Zweig might help Lord Cameron and all concerned: "He thrives on conflict between the two sides. When relations are harmonious and smooth, his existence—like a doctor's—is hardly noticed. The firm often backs him up and welcomes his services: at other times it looks at him askance, suspecting ill-will and mischief. He is a product of the firm's attitude to its employees and to him. Every firm breeds its own type of shop steward, which after a certain time is fixed and incorporated in tradition, and is then difficult to change."

Art of Firemanship

The use of unskilled labour for the stoking of boilers was severely criticised by a consulting engineer speaking at a meeting of the Royal Society of Health at Bolton, last week. Pointing out that one man firing two Lancashire boilers could easily spend £10,000 a year of the firm's money in coal, he asked "is it good business to allow an untrained man to handle such a sum?"

British Railways are troubled by similar problems, and are concerned both with the effect of black smoke on the atmosphere and the appalling waste of fuel it implies. The British Transport Commission have issued an attractive little booklet entitled *Good Firemanship* for the guidance of their steam locomotive staff. It is a statement, illustrated in colour, of the principles which govern efficient combustion of coal. Not enough air and too much coal is the usual trouble, but no rules can be laid down. The best firemen "produce the most steam and with the least coal and at the right time." Practical tests have revealed that most firemen burn far too much coal, "because they are firing irregularly and too heavily on the hills, or regularly and too often for good combustion." As in most occupations the difference between the best and the poorest was found to be "much greater than was expected"—and this in 1957, after over a century of steam traction.

More Deadly than the Male

The first scholarship in engineering awarded by Hoover Limited has been won by a girl student of the Harrow County Girls' School. She was the only woman in the examination recently held but "proved well in advance of the other contestants."

The scholarship is for an honours course in mechanical engineering tenable at Southampton University. The winner, Miss V. Blois, will spend three years at the University and two years under instruction at Hoover establishments. Each of the three scholarships granted by the firm is worth £1,900 over the total period of study; in addition four exhibitions are to be awarded annually for courses at technical colleges for diplomas in technology, each worth £1,200.

These sums are well within the reach of at least 200 companies in the engineering and metal industries. The National Institute of Economic and Social Research's classified list of large companies showed that in 1953/4 there were 173 firms with net assets exceeding £2½ million. If all did like Hoover, over 500 graduate engineers and 700 technicians would become available each year. That the first successful candidate should be a girl draws attention to a largely untapped source of talent.

Wage Storms Abroad

Britain is not alone in her labour troubles. Both Germany and Japan appear to be entering a most disturbed period, with heavy upward pressure on wages and threats of national strikes abounding. So far they have done well; earnings have risen since the war much less than productivity. Partly perhaps because the supply of labour was more plentiful (Germany had the refugees from the East), partly because capital investment was at a greater rate. Such advantages are now less, and the patience of organised labour is wearing thin.

In Germany last year earnings rose by 10 per cent. and wage levels by 9 per cent. In the United Kingdom the corresponding figures were about 5½ and 6 per cent. In Japan earnings were up by over 7 per cent. There is evidence that the process is continuing and that the disparity between the cost of labour in the three countries will become less. The German unions are very determined to secure higher wages and do not appear unduly perturbed by Dr. Erhard, the Minister of Economic Affairs, when he threatens to break the wage spiral "if necessary with brute force." Compared with the average Briton, the German does very poorly: he is determined to get a bigger share of the very rich national cake he has helped to make.

In Japan unrest is even worse. About 3½ million workers belonging to 18 unions are preparing for a trial of strength with the Government and management. They want an increase of 25 per cent. in the minimum monthly wage. Coal miners have already stopped work twice; railway workers are having a series of short strikes which disrupt the economy. But, as in Germany, the workers see large profits everywhere and are beginning to know their strength.

Medicine and Duties

"The doctor flatly refused to give my husband a certificate, and it upset him so much that he became ill." This could have been said by any man's wife, in any country. It was the caption of a cartoon in *Krokodil*, the Russian equivalent of Punch. Another cartoon showed a young man displaying his rippling muscles to his medical examiners "before entering the technical school" and returning round-shouldered and glum, with sheaves of medical certificates "when summoned for duty in the provinces."

The above are quoted in an article entitled "The Soviet Doctor's Dilemma" in a recent issue of *Problems of Communism* published by the U.S. Information Service. Doctors are frequently condemned "for excessive goodness of heart, gullibility, indifference or irresponsibility" in the indiscriminate granting of certificates of sickness. It may be, of course that, Soviet doctors—like their British colleagues—are too busy to convince a man who pretends to be sick that he is not. It is easier, and perhaps fairer to the genuinely sick, to play safe and send him packing with a certificate.

One day, perhaps, to be allowed to work will be so great an honour that the average doctor's work will be much lightened. So far, in Russia no less than elsewhere, many find work an awful bind and would willingly trade a little of their sick pay for a few days off. It appears that neither Soviet nor British doctors have yet evolved a response to the malingerer as effective as the Army M.O.'s "medicine and duties."